Fig. 1

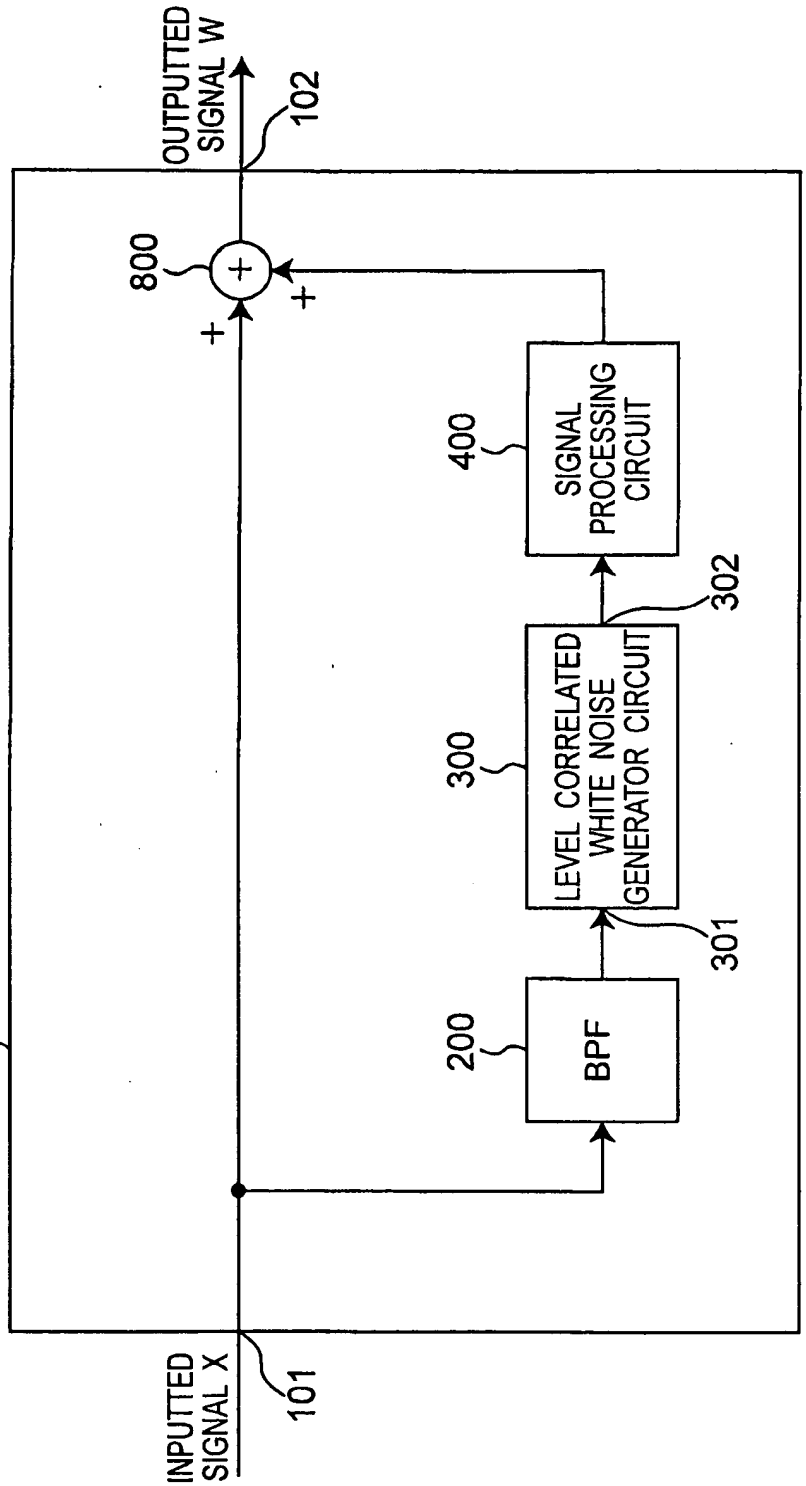

AUDIO BAND EXTENSION APPARATUS 100-1
INPUTTED SIGNAL X
101
OUTPUTTED SIGNAL W
102
800
+
+
+
200
BPF
300
LEVEL CORRELATED WHITE NOISE GENERATOR CIRCUIT
301
302
400
SIGNAL PROCESSING CIRCUIT

Fig.2

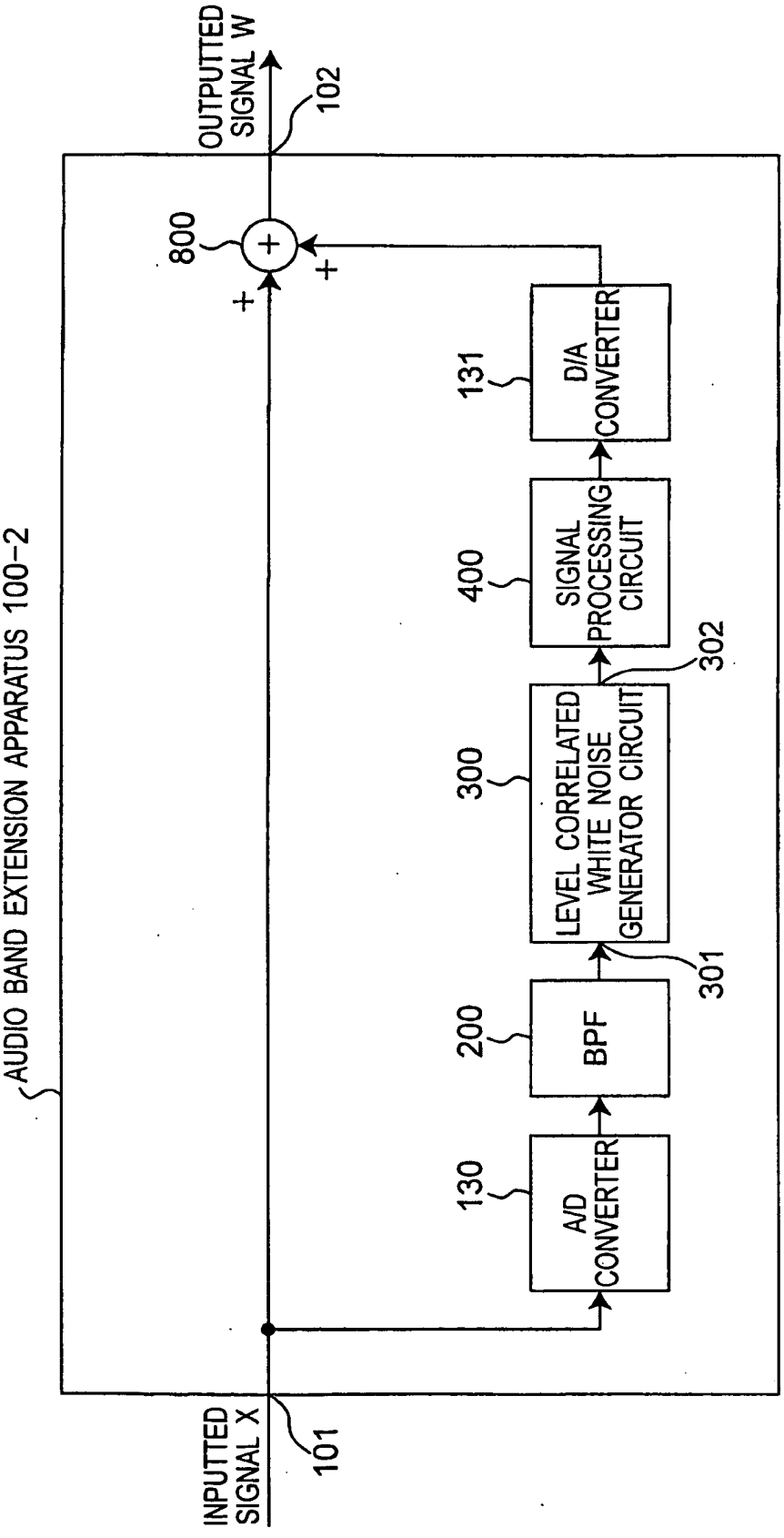

AUDIO BAND EXTENSION APPARATUS 100-2
INPUTTED SIGNAL X
101
OUTPUTTED SIGNAL W
102
800
+
+
+
130
A/D CONVERTER
200
BPF
300
LEVEL CORRELATED WHITE NOISE GENERATOR CIRCUIT
301
302
400
SIGNAL PROCESSING CIRCUIT
131
D/A CONVERTER

Fig.3

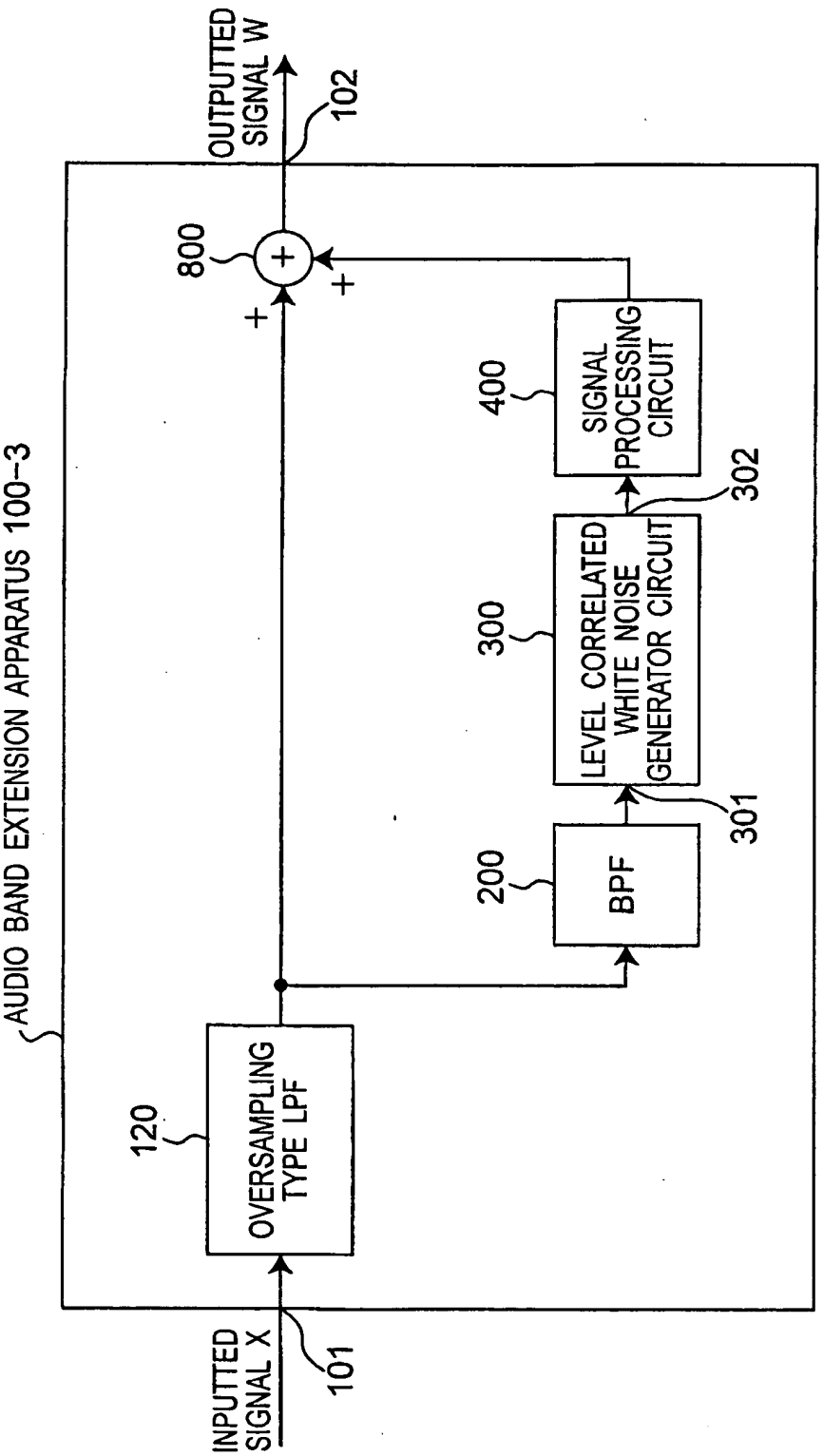

AUDIO BAND EXTENSION APPARATUS 100-3
INPUTTED SIGNAL X
101
OUTPUTTED SIGNAL W
102
120
OVERSAMPLING TYPE LPF
200
BPF
300
LEVEL CORRELATED WHITE NOISE GENERATOR CIRCUIT
301
302
400
SIGNAL PROCESSING CIRCUIT
800
+
+
+

Fig.4

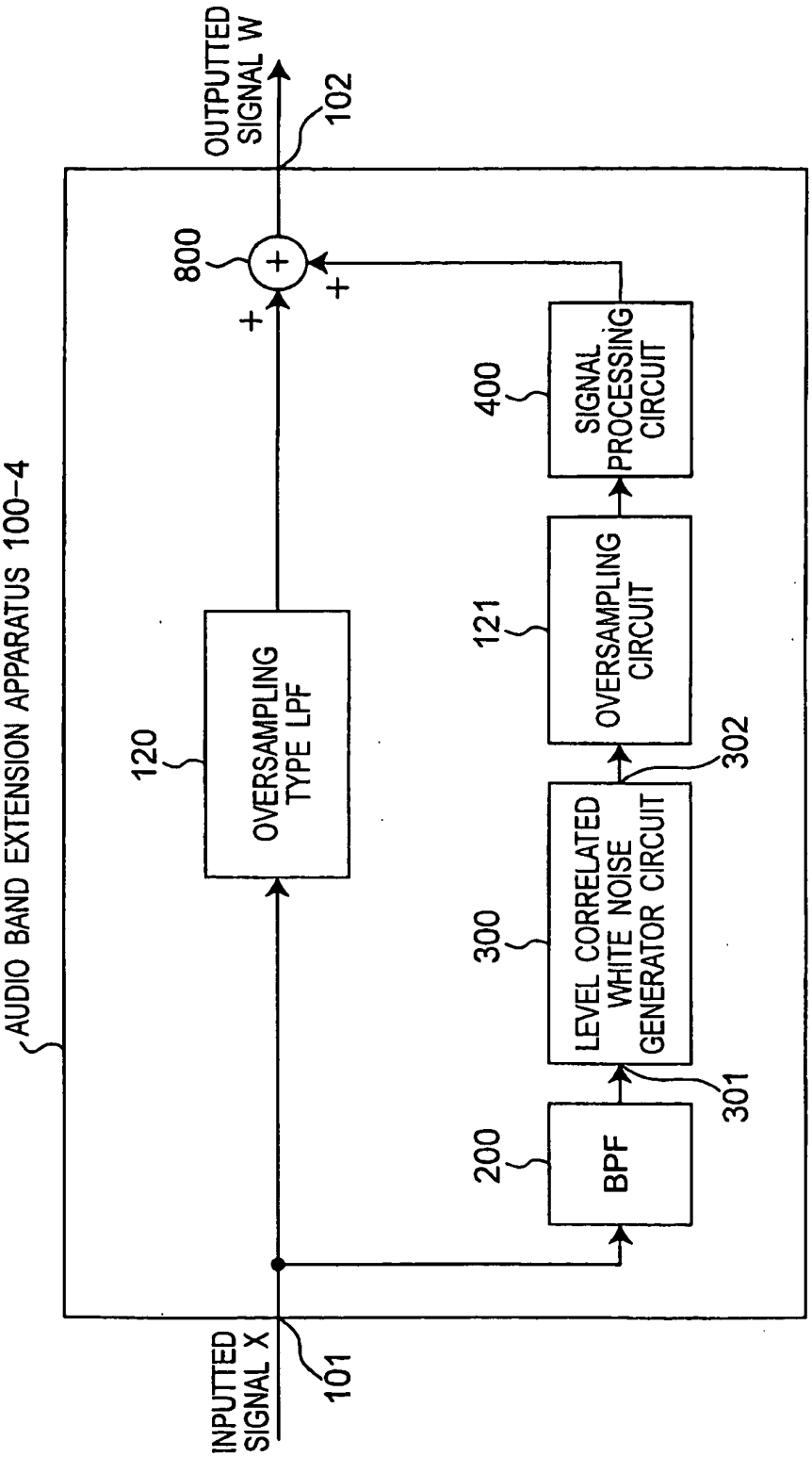

AUDIO BAND EXTENSION APPARATUS 100-4
INPUTTED SIGNAL X
101
OUTPUTTED SIGNAL W
102
800
+
+
+
120
OVERSAMPLING TYPE LPF
200
BPF
300
LEVEL CORRELATED WHITE NOISE GENERATOR CIRCUIT
301
302
121
OVERSAMPLING CIRCUIT
400
SIGNAL PROCESSING CIRCUIT

Fig.5

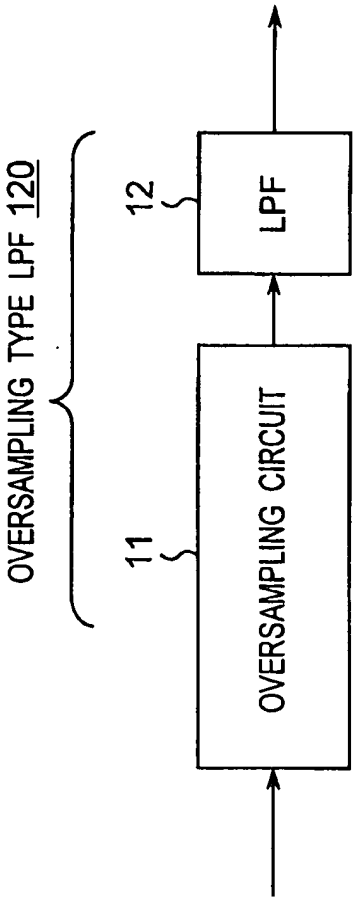


Fig.6

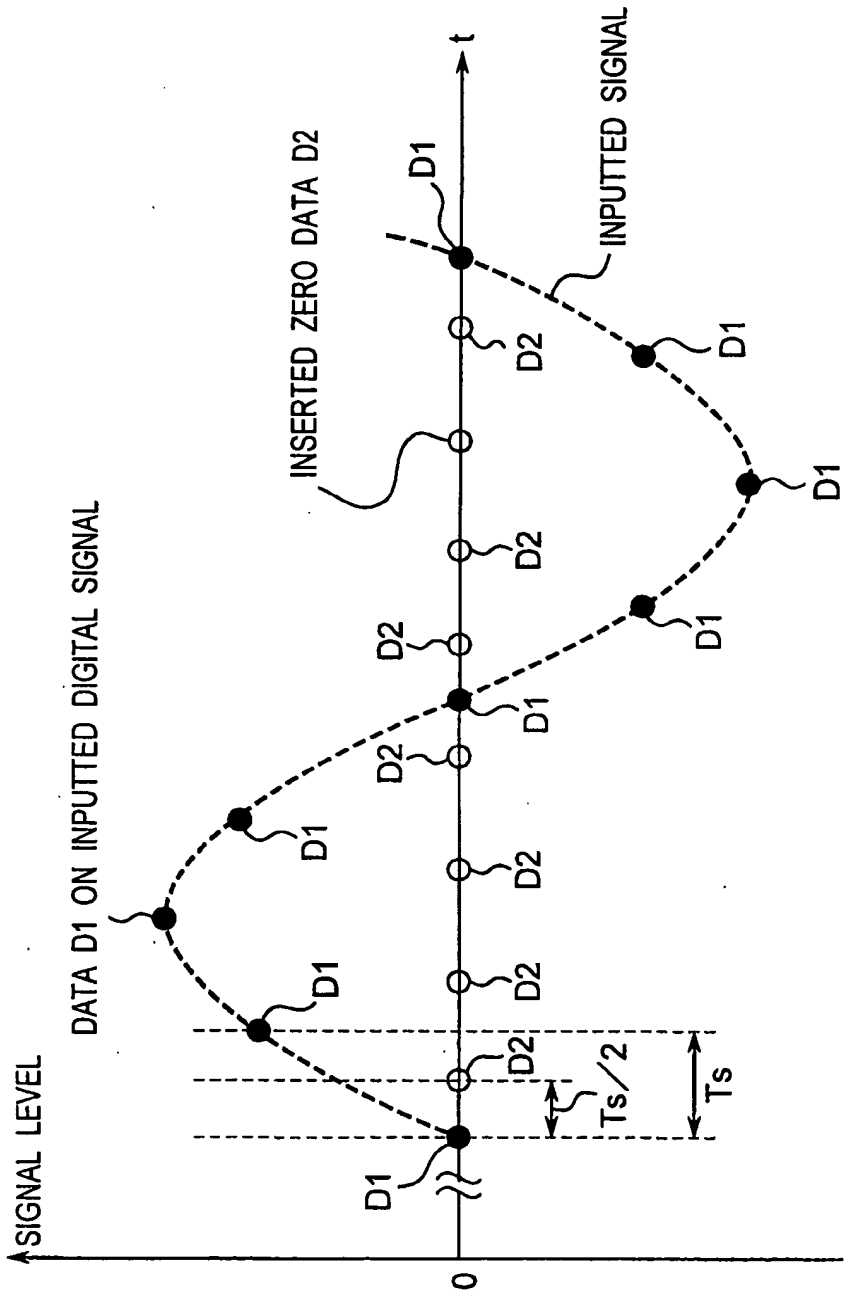

SIGNAL LEVEL
DATA D1 ON INPUTTED DIGITAL SIGNAL
INSERTED ZERO DATA D2
INPUTTED SIGNAL
t
0
D1
D2
Ts/2
Ts

Fig.7

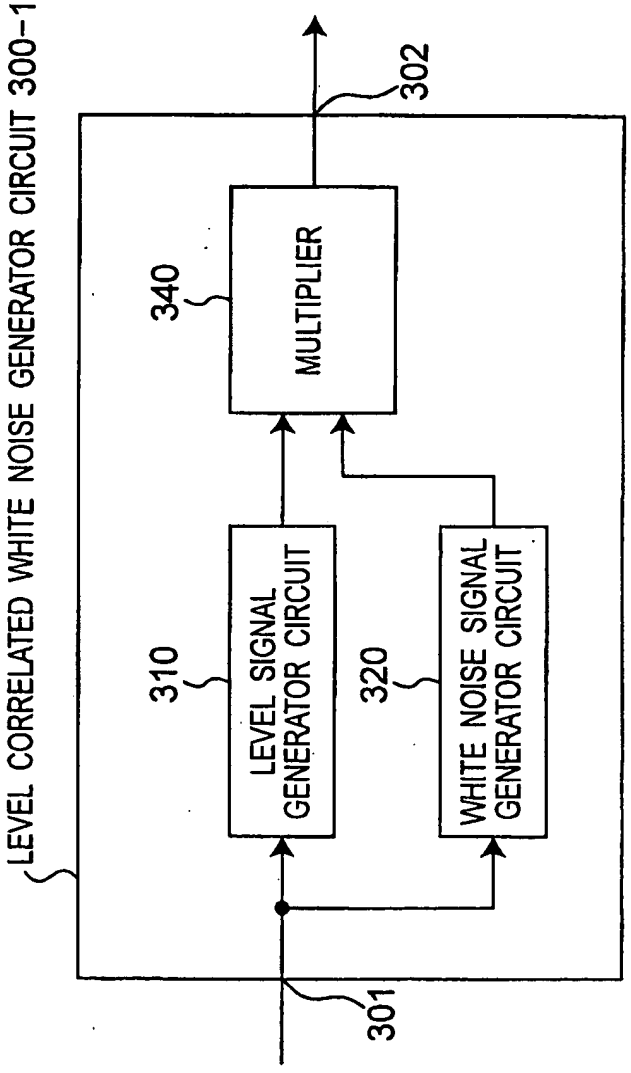

LEVEL CORRELATED WHITE NOISE GENERATOR CIRCUIT 300-1
302
340
MULTIPLIER
310
LEVEL SIGNAL GENERATOR CIRCUIT
320
WHITE NOISE SIGNAL GENERATOR CIRCUIT
301

Fig.8

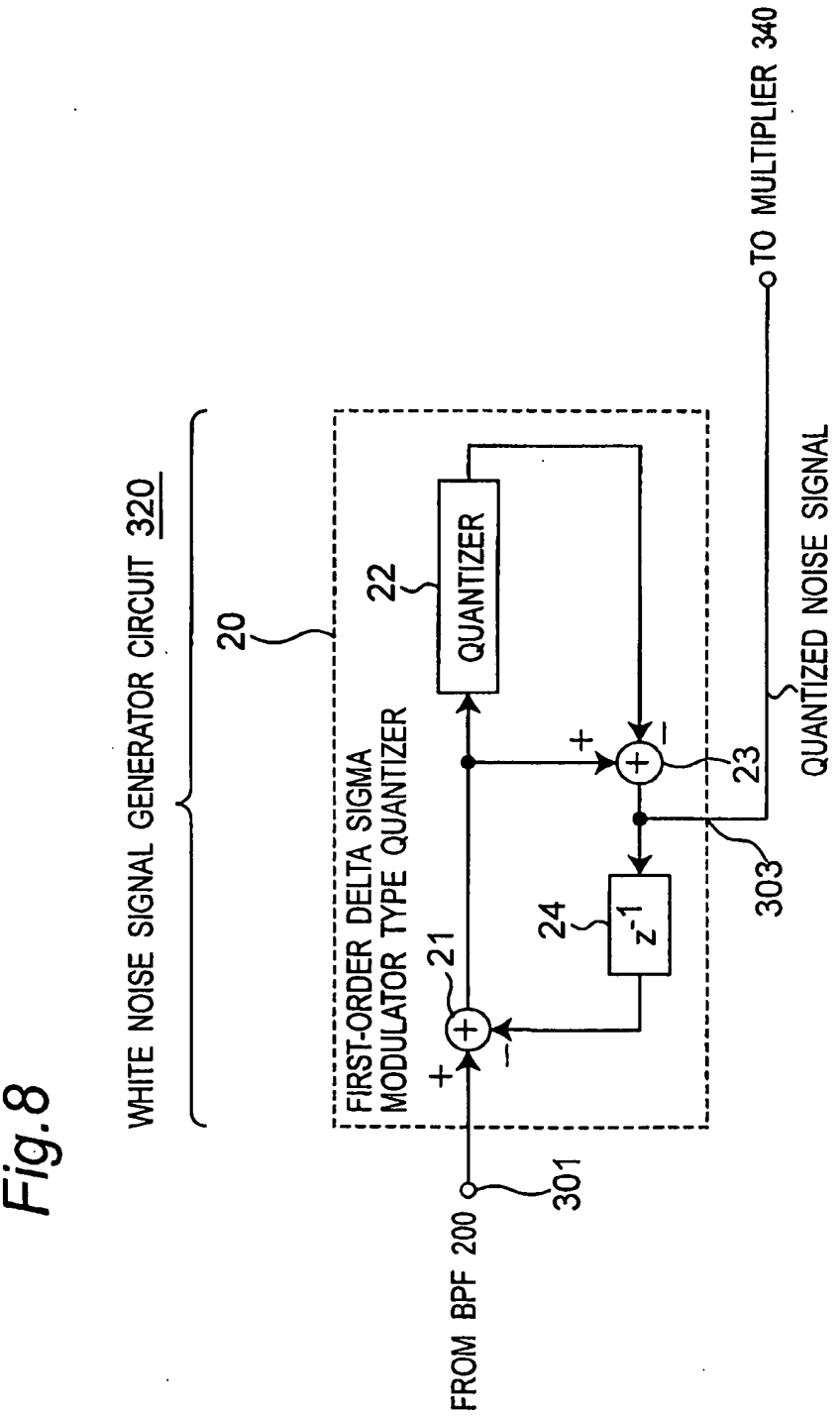

WHITE NOISE SIGNAL GENERATOR CIRCUIT 320
20
FIRST-ORDER DELTA SIGMA MODULATOR TYPE QUANTIZER
22
QUANTIZER
21
24
z^{-1}
23
303
301
FROM BPF 200
TO MULTIPLIER 340
QUANTIZED NOISE SIGNAL

Fig.9

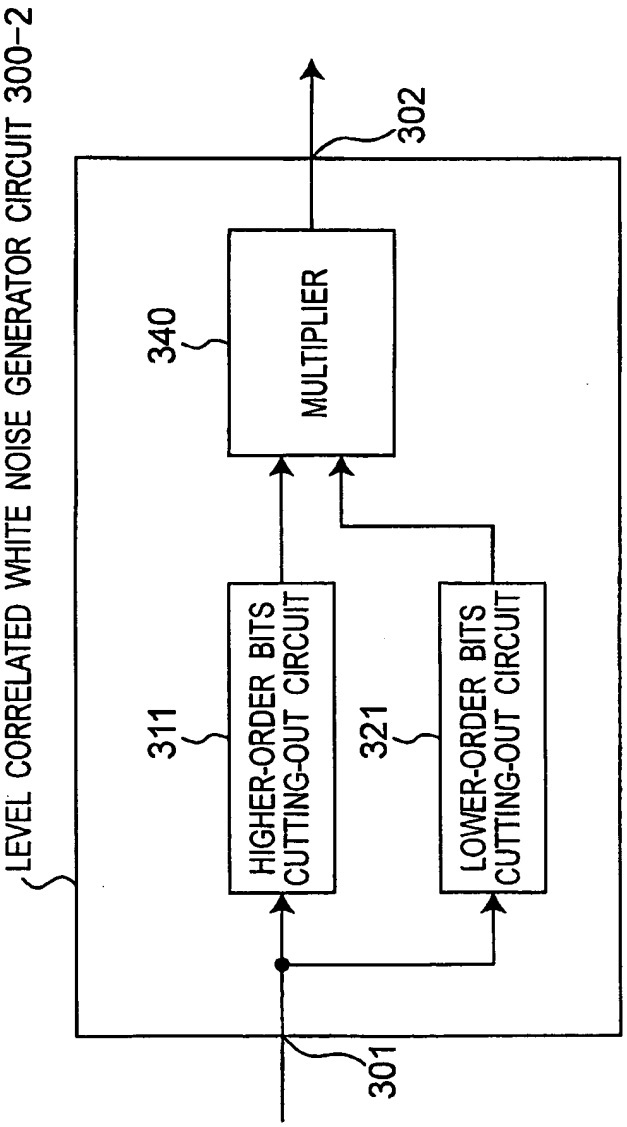

LEVEL CORRELATED WHITE NOISE GENERATOR CIRCUIT 300-2
302
340
MULTIPLIER
311
HIGHER-ORDER BITS CUTTING-OUT CIRCUIT
321
LOWER-ORDER BITS CUTTING-OUT CIRCUIT
301

Fig. 10

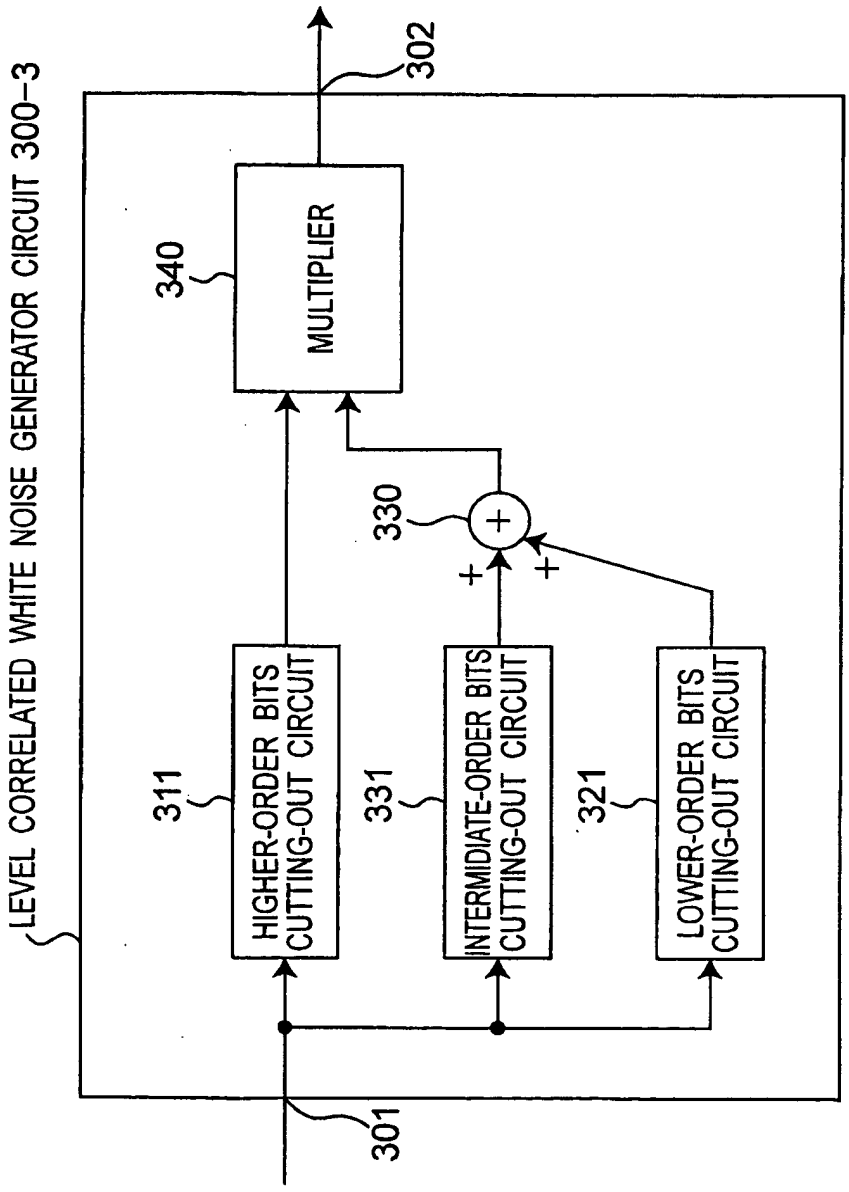

LEVEL CORRELATED WHITE NOISE GENERATOR CIRCUIT 300-3
302
340
MULTIPLIER
330
+
+
+
311
HIGHER-ORDER BITS CUTTING-OUT CIRCUIT
331
INTERMIDIATE-ORDER BITS CUTTING-OUT CIRCUIT
321
LOWER-ORDER BITS CUTTING-OUT CIRCUIT
301

Fig. 11

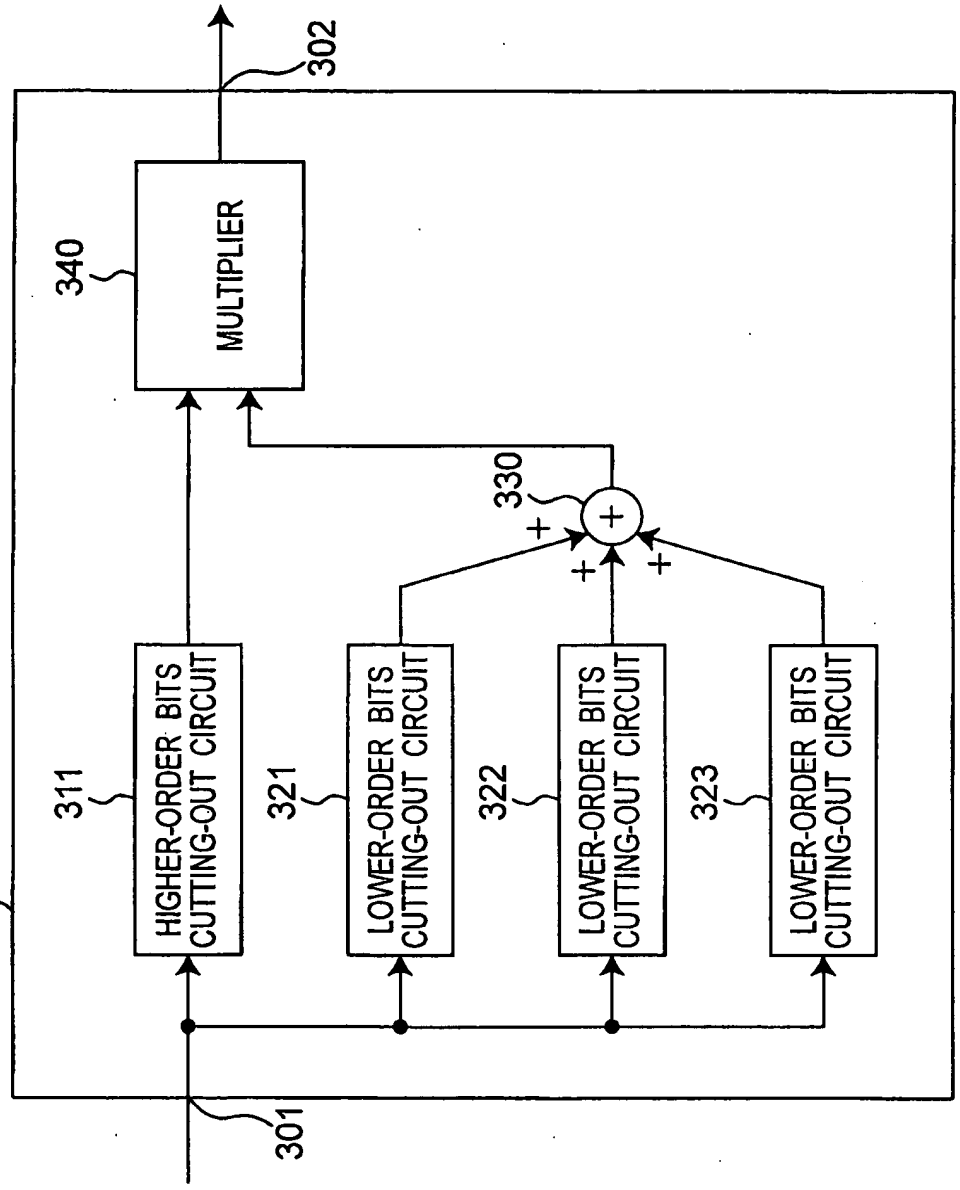

LEVEL CORRELATED WHITE NOISE GENERATOR CIRCUIT 300-4
302
340
MULTIPLIER
330
+
+
+
+
311
HIGHER-ORDER BITS CUTTING-OUT CIRCUIT
321
LOWER-ORDER BITS CUTTING-OUT CIRCUIT
322
LOWER-ORDER BITS CUTTING-OUT CIRCUIT
323
LOWER-ORDER BITS CUTTING-OUT CIRCUIT
301

Fig.12

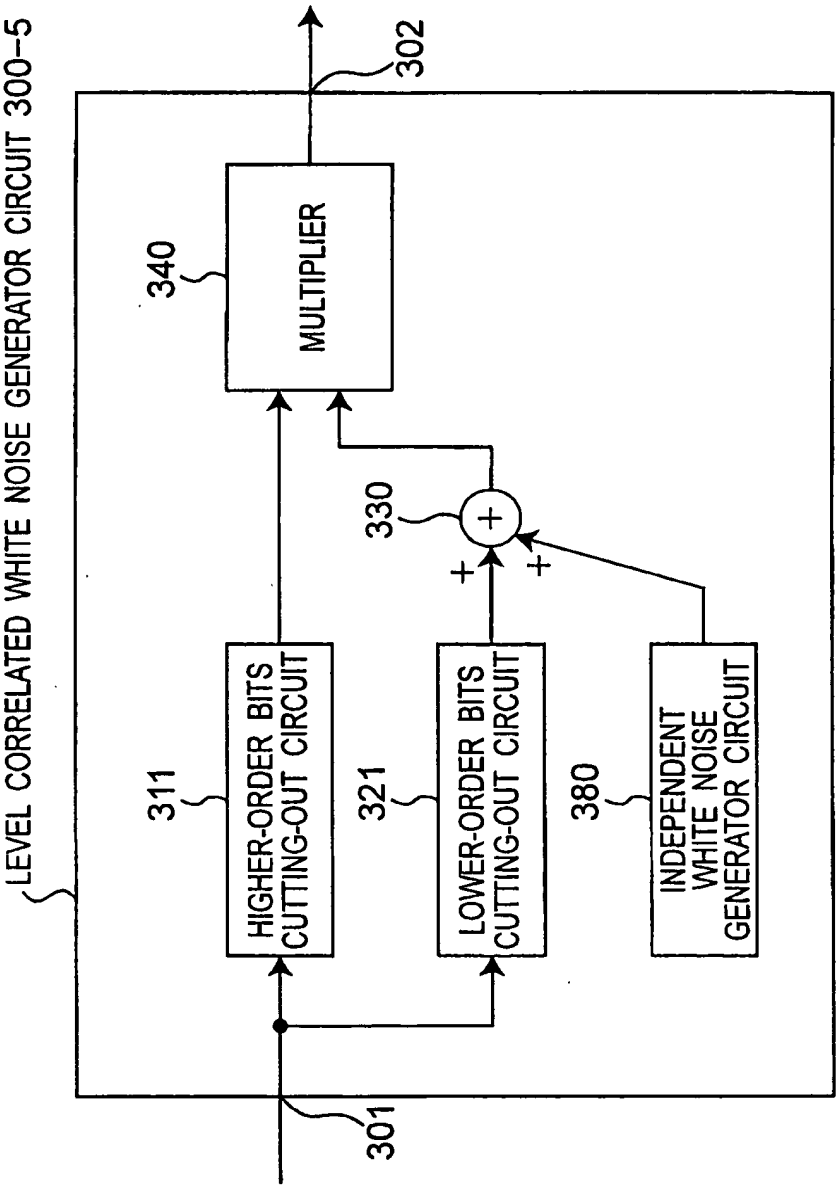

LEVEL CORRELATED WHITE NOISE GENERATOR CIRCUIT 300-5
302
340
MULTIPLIER
330
+
+
+
311
HIGHER-ORDER BITS CUTTING-OUT CIRCUIT
321
LOWER-ORDER BITS CUTTING-OUT CIRCUIT
380
INDEPENDENT WHITE NOISE GENERATOR CIRCUIT
301

Fig.13

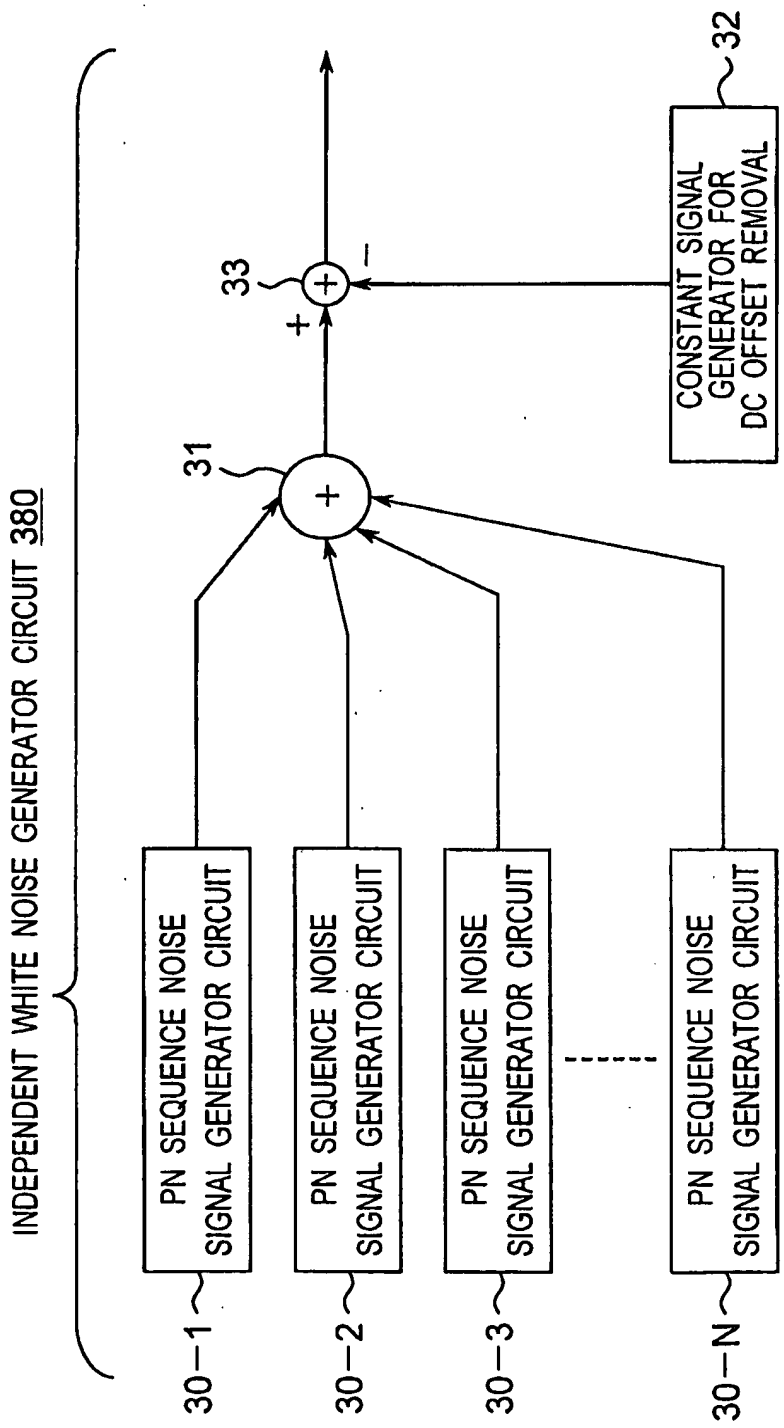

INDEPENDENT WHITE NOISE GENERATOR CIRCUIT 380
PN SEQUENCE NOISE SIGNAL GENERATOR CIRCUIT
PN SEQUENCE NOISE SIGNAL GENERATOR CIRCUIT
PN SEQUENCE NOISE SIGNAL GENERATOR CIRCUIT
PN SEQUENCE NOISE SIGNAL GENERATOR CIRCUIT
30−1
30−2
30−3
30−N
31
33
+
+
−
CONSTANT SIGNAL GENERATOR FOR DC OFFSET REMOVAL
32

Fig.14

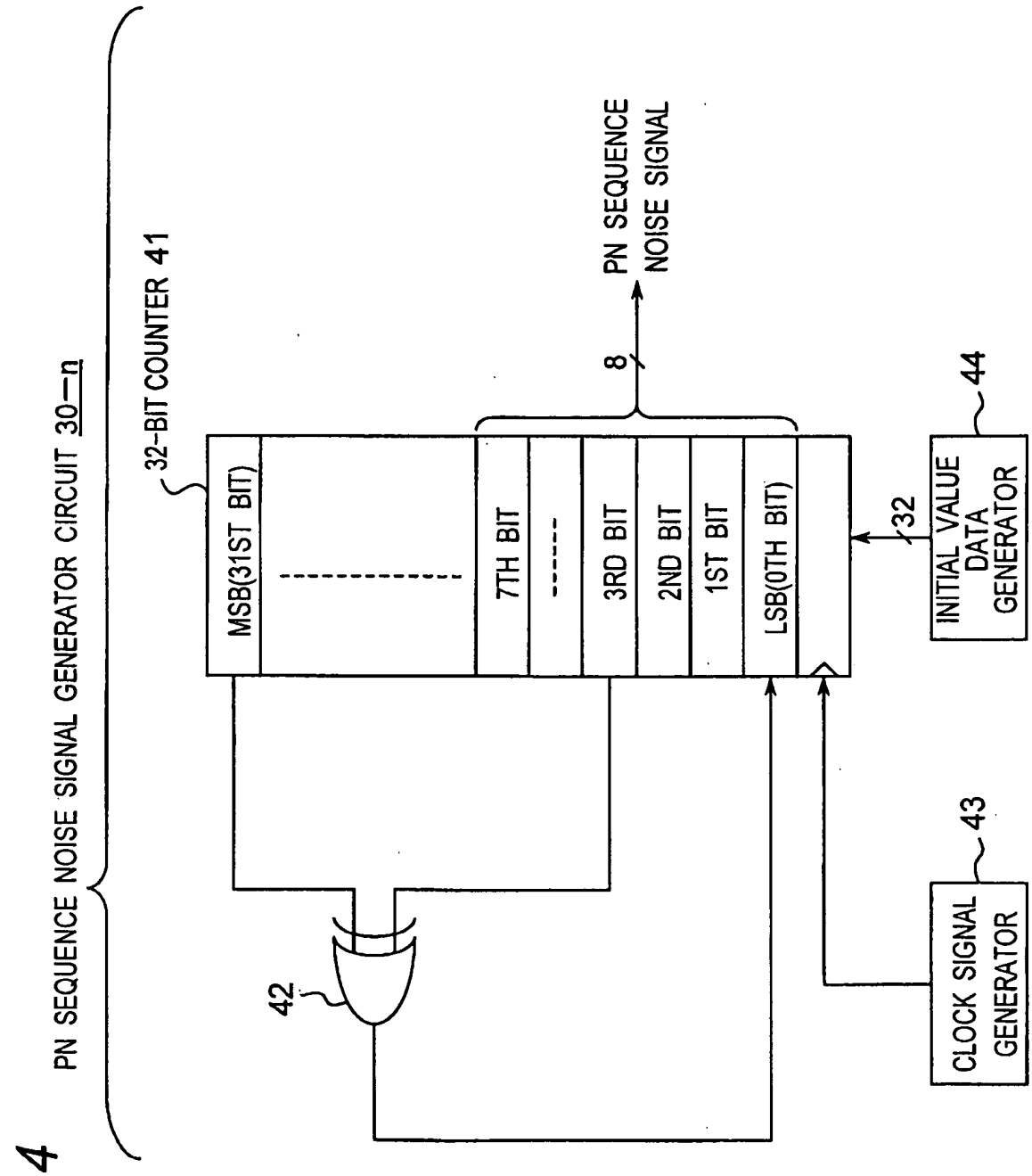

PN SEQUENCE NOISE SIGNAL GENERATOR CIRCUIT 30—n
32-BIT COUNTER 41
MSB(31ST BIT)
7TH BIT
3RD BIT
2ND BIT
1ST BIT
LSB(0TH BIT)
8
PN SEQUENCE NOISE SIGNAL
32
INITIAL VALUE DATA GENERATOR
44
42
CLOCK SIGNAL GENERATOR
43

Fig. 15

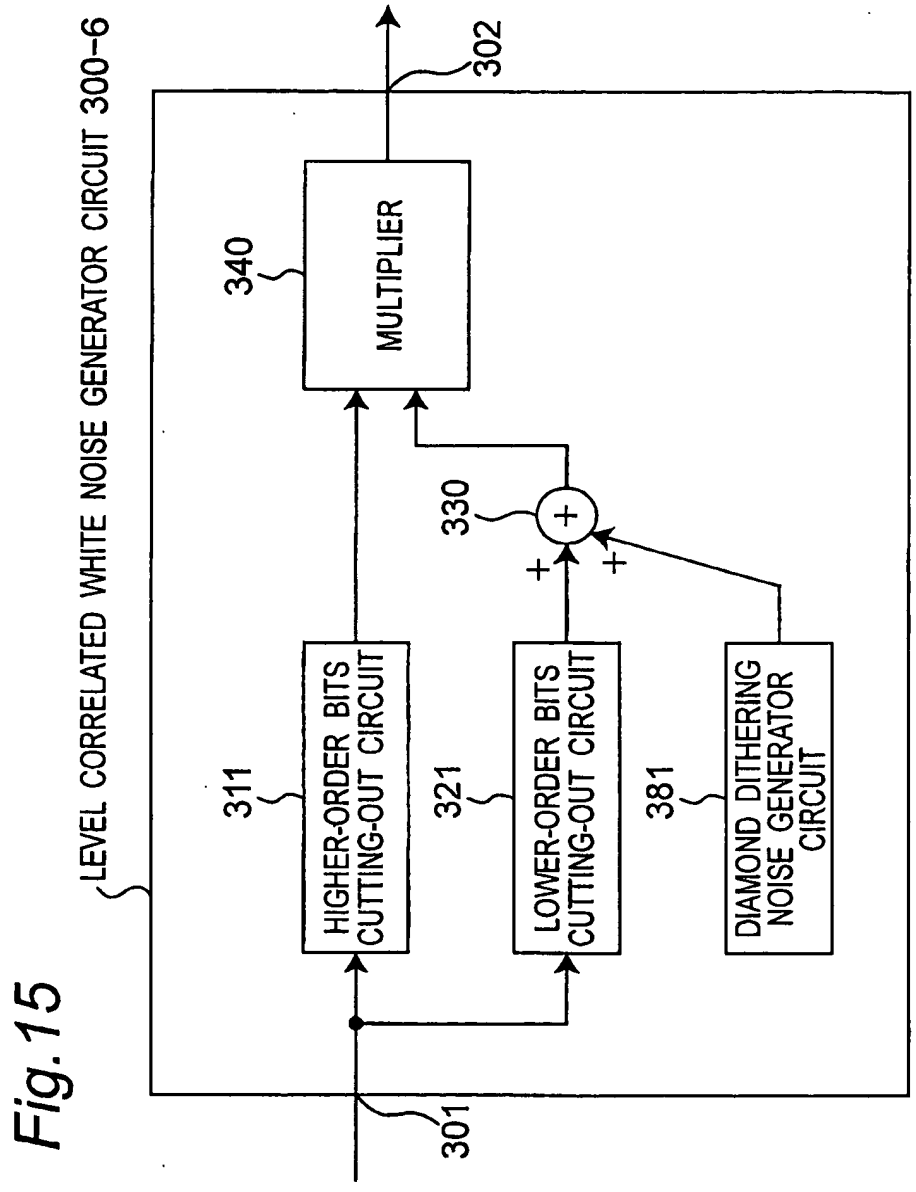

LEVEL CORRELATED WHITE NOISE GENERATOR CIRCUIT 300-6
301
302
311
HIGHER-ORDER BITS CUTTING-OUT CIRCUIT
321
LOWER-ORDER BITS CUTTING-OUT CIRCUIT
381
DIAMOND DITHERING NOISE GENERATOR CIRCUIT
330
+
+
+
340
MULTIPLIER

Fig.16A

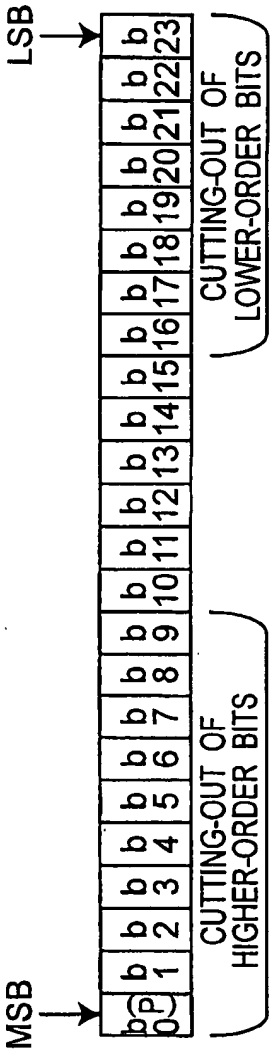


Fig.16B

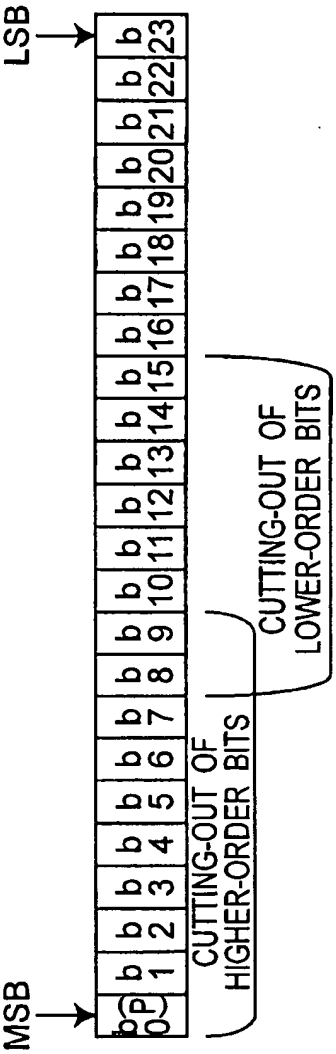


Fig.17A

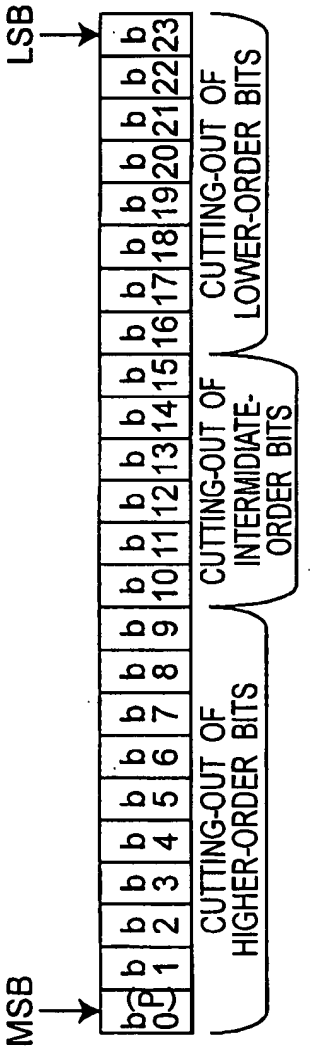


Fig.17B

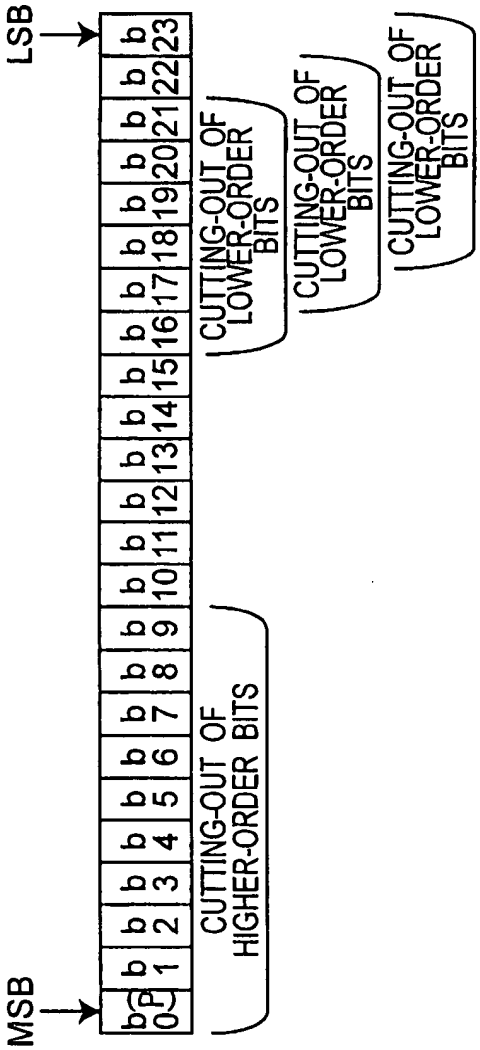


Fig.18A

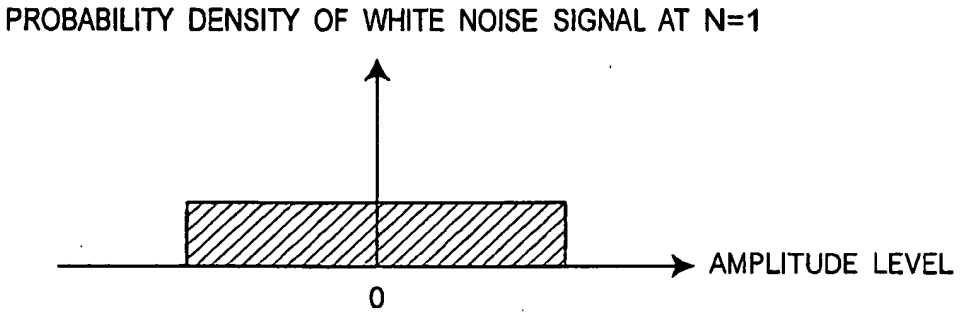


Fig.18B

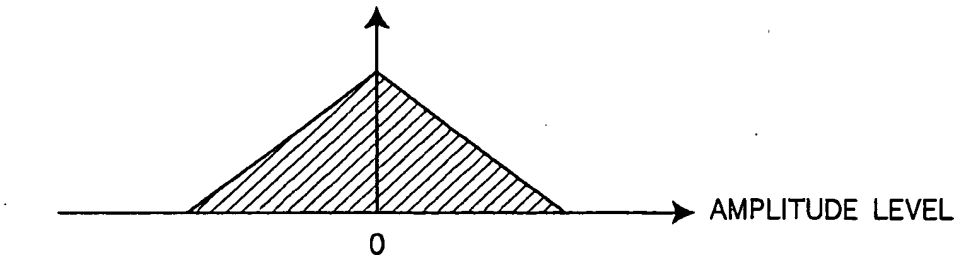


Fig.18C

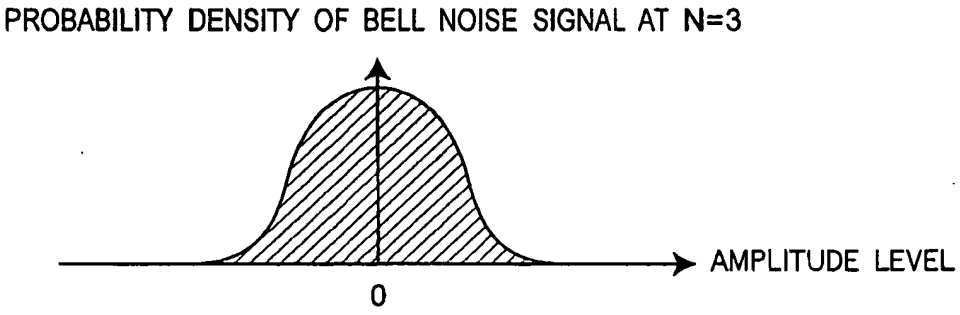


Fig.19

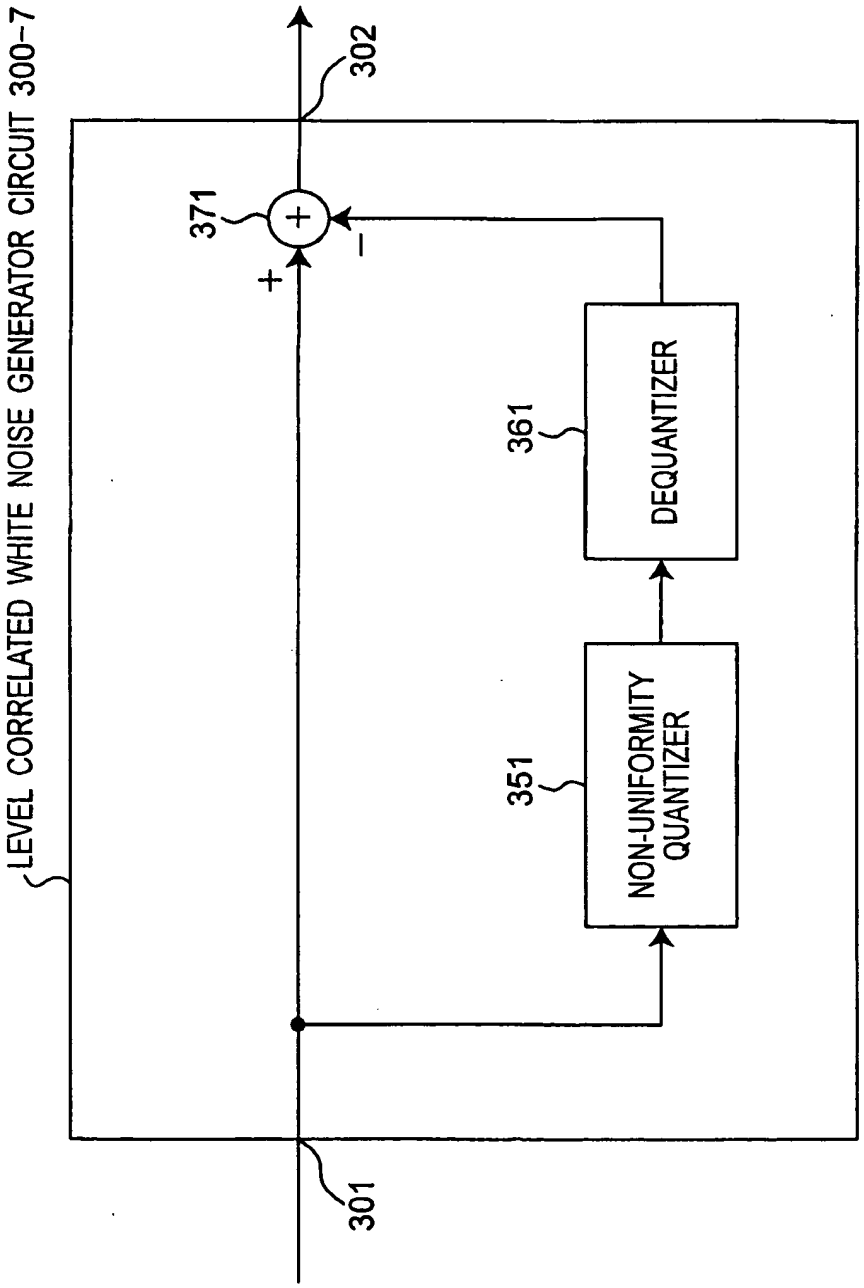

LEVEL CORRELATED WHITE NOISE GENERATOR CIRCUIT 300-7
302
371
+
−
+
361
DEQUANTIZER
351
NON-UNIFORMITY QUANTIZER
301

Fig.20

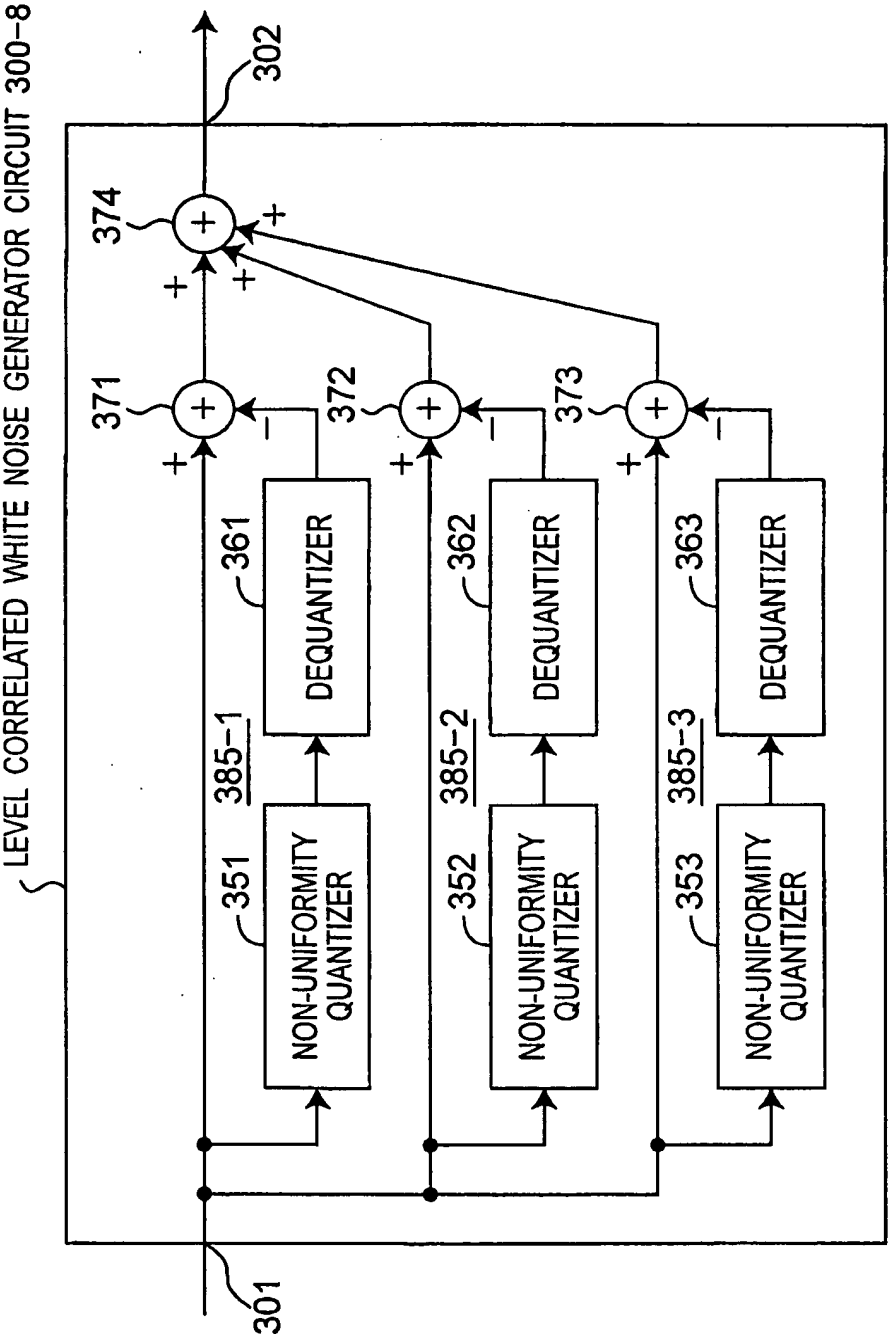

LEVEL CORRELATED WHITE NOISE GENERATOR CIRCUIT 300-8
301
302
374
371
372
373
361
362
363
385-1
385-2
385-3
351
352
353
NON-UNIFORMITY QUANTIZER
DEQUANTIZER
+
-

Fig.21

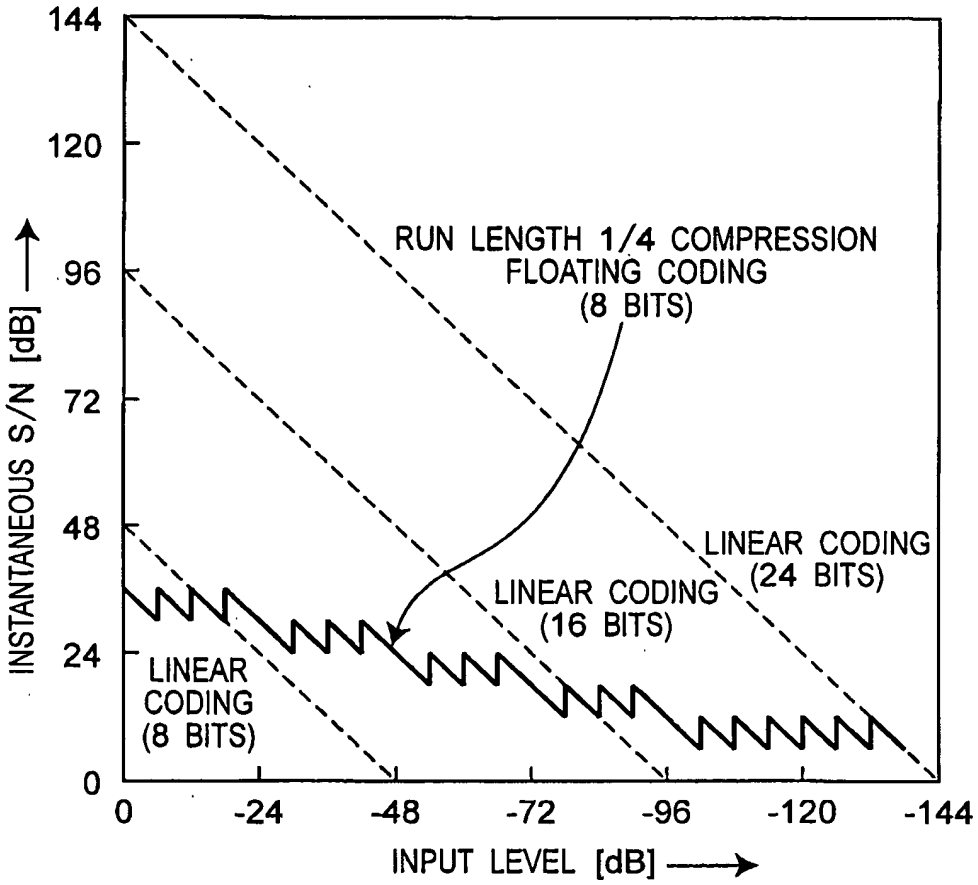

144
120
96
72
48
24
0
INSTANTANEOUS S/N [dB]
RUN LENGTH 1/4 COMPRESSION
FLOATING CODING
(8 BITS)
LINEAR CODING
(24 BITS)
LINEAR CODING
(16 BITS)
LINEAR
CODING
(8 BITS)
0
-24
-48
-72
-96
-120
-144
INPUT LEVEL [dB]

Fig.22

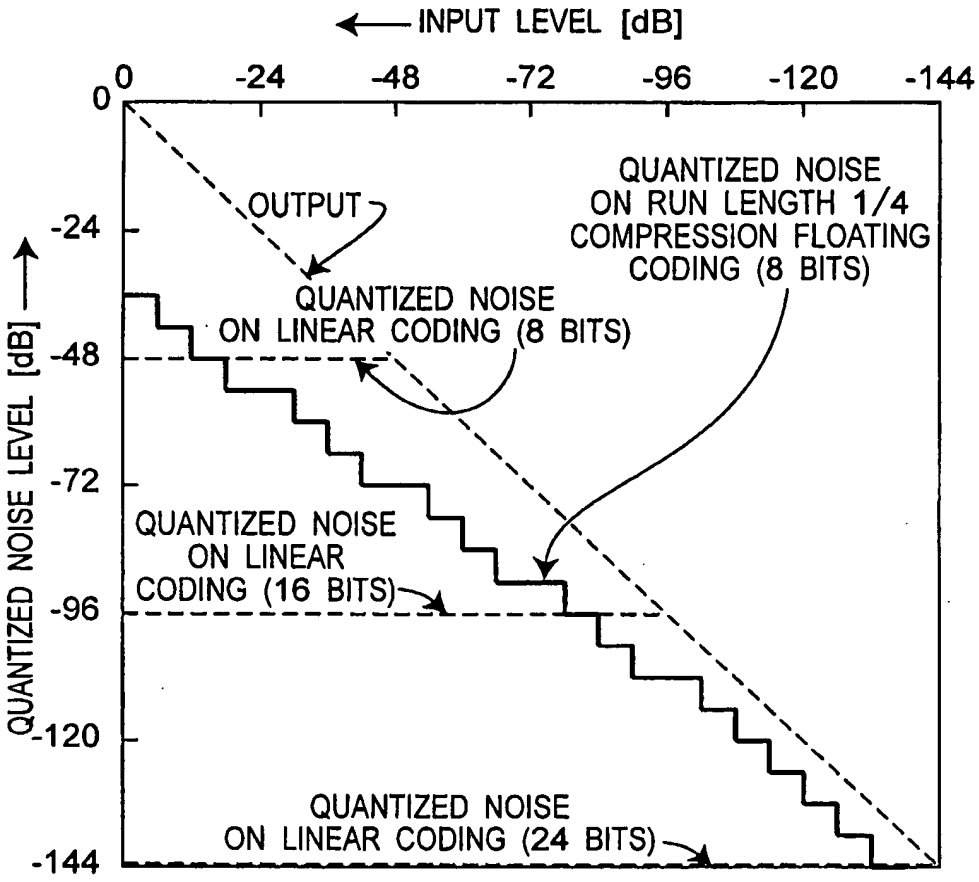

INPUT LEVEL [dB]
0
-24
-48
-72
-96
-120
-144
QUANTIZED NOISE LEVEL [dB]
OUTPUT
QUANTIZED NOISE ON RUN LENGTH 1/4 COMPRESSION FLOATING CODING (8 BITS)
QUANTIZED NOISE ON LINEAR CODING (8 BITS)
QUANTIZED NOISE ON LINEAR CODING (16 BITS)
QUANTIZED NOISE ON LINEAR CODING (24 BITS)

Fig.23A

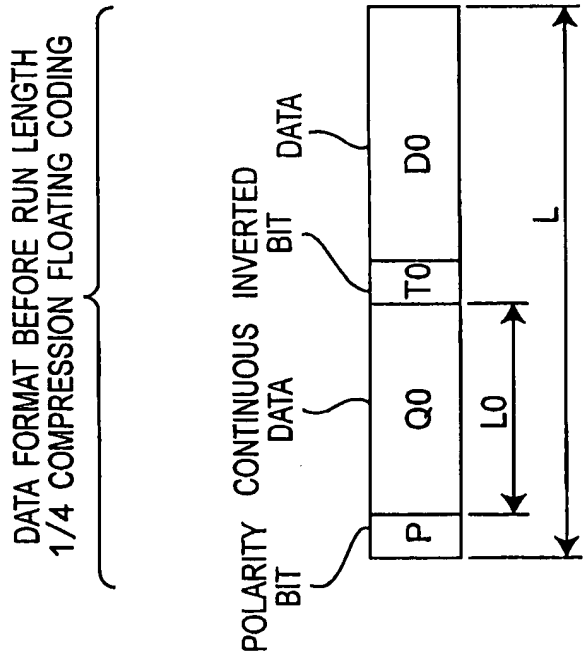


Fig.23B

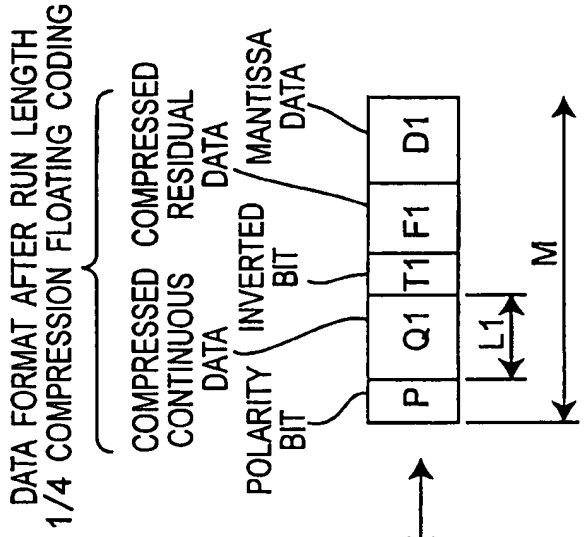


Fig.24

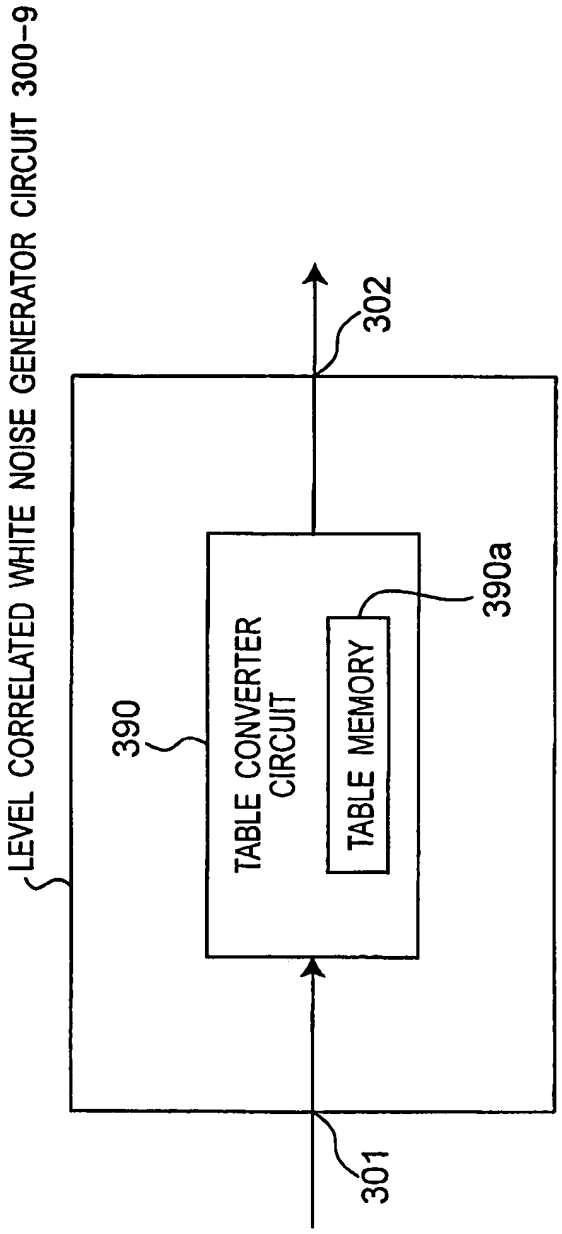

LEVEL CORRELATED WHITE NOISE GENERATOR CIRCUIT 300-9
302
390
TABLE CONVERTER CIRCUIT
TABLE MEMORY
390a
301

Fig.25

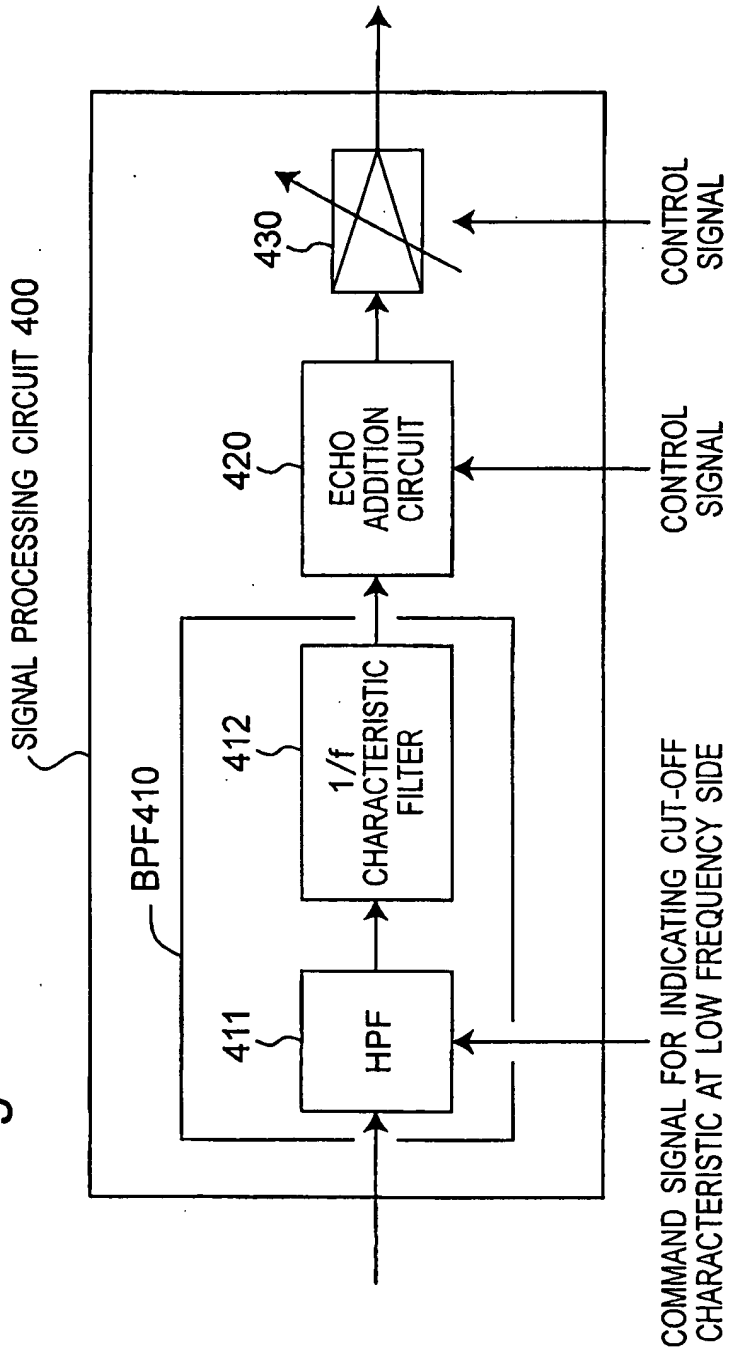

SIGNAL PROCESSING CIRCUIT 400
BPF410
411
HPF
412
1/f CHARACTERISTIC FILTER
420
ECHO ADDITION CIRCUIT
430
CONTROL SIGNAL
CONTROL SIGNAL
COMMAND SIGNAL FOR INDICATING CUT-OFF CHARACTERISTIC AT LOW FREQUENCY SIDE

Fig.26

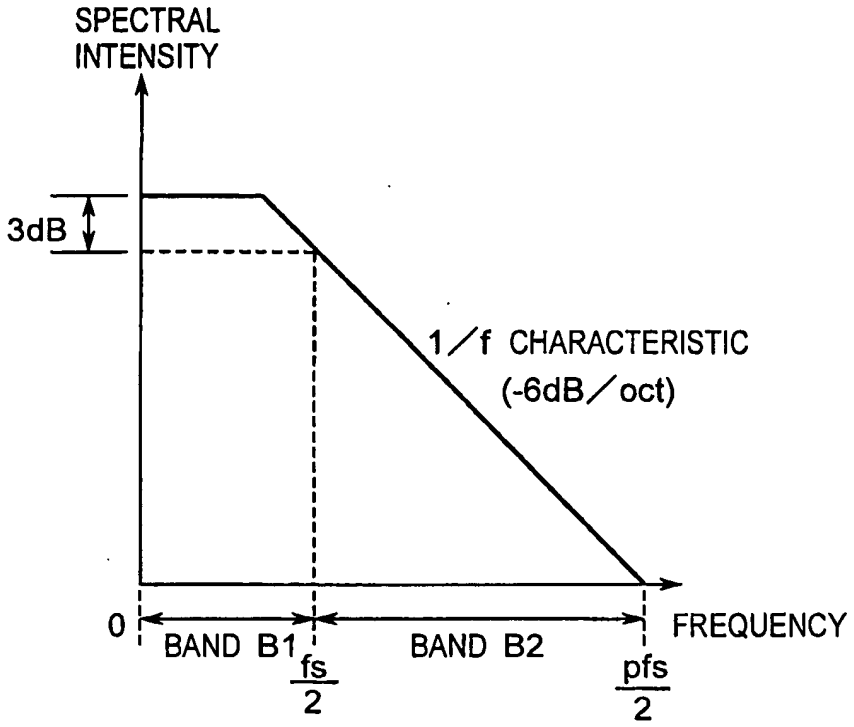

SPECTRAL
INTENSITY
3dB
1/f CHARACTERISTIC
(-6dB/oct)
0
BAND B1
BAND B2
FREQUENCY
fs/2
pfs/2

Fig.27

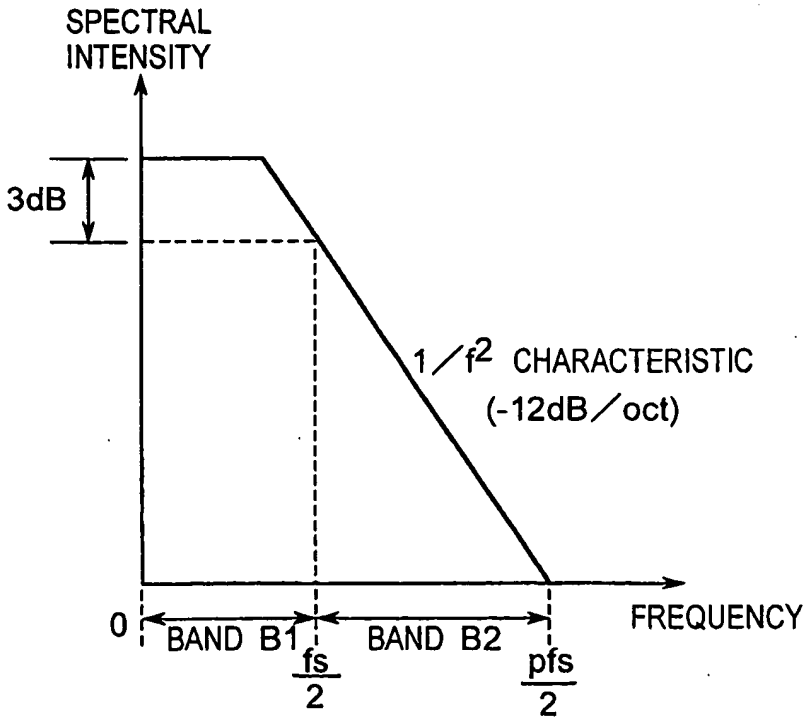

SPECTRAL
INTENSITY
3dB
1/f2 CHARACTERISTIC
(-12dB/oct)
0
BAND B1
BAND B2
FREQUENCY
fs/2
pfs/2

Fig.28

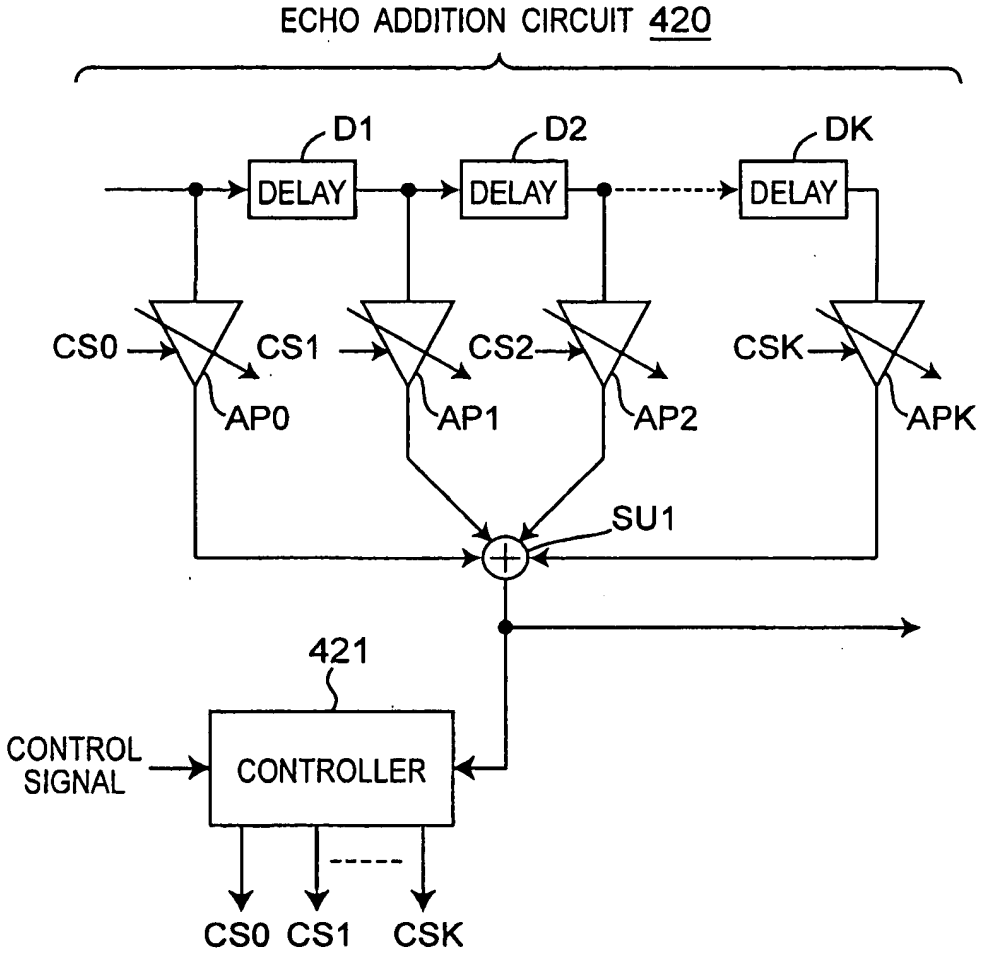

ECHO ADDITION CIRCUIT 420
D1
D2
DK
DELAY
DELAY
DELAY
CS0
CS1
CS2
CSK
AP0
AP1
AP2
APK
SU1
421
CONTROL SIGNAL
CONTROLLER
CS0 CS1 CSK

Fig.29A

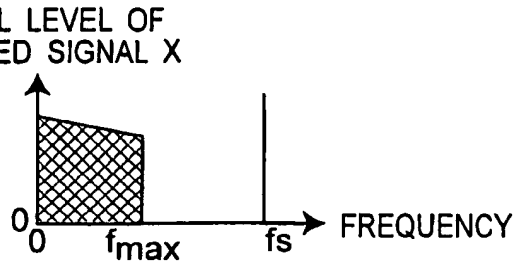


Fig.29B

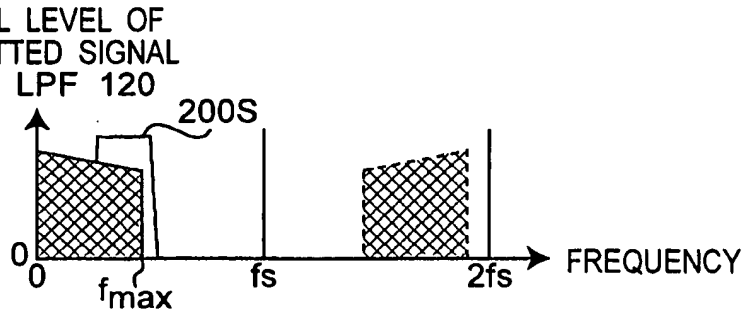


Fig.29C

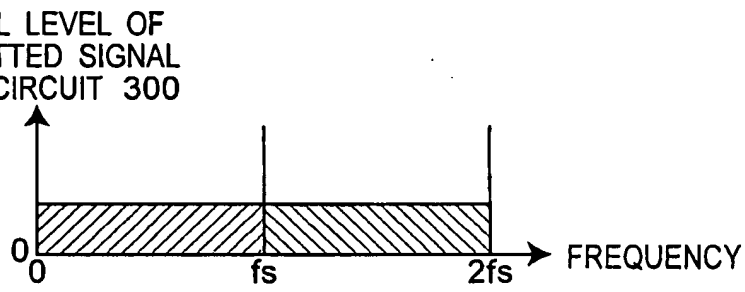


Fig.29D

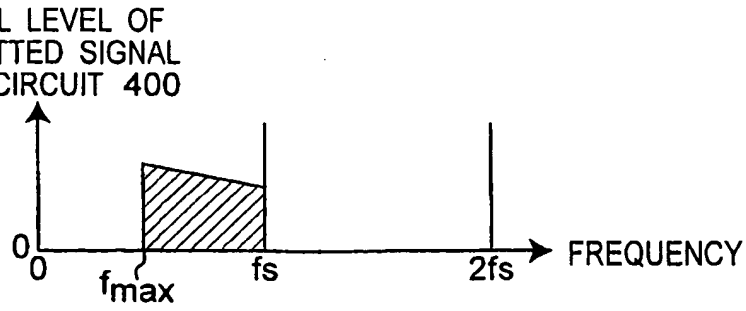


Fig.29E

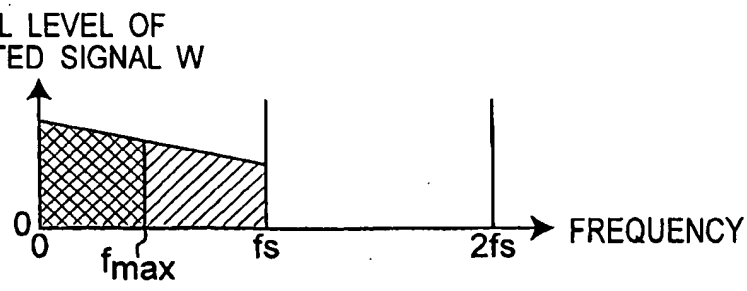


Fig.30A

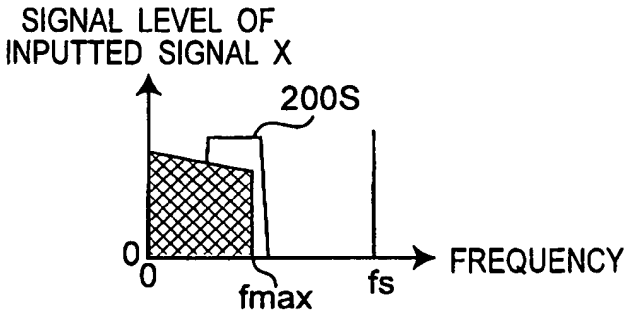


Fig.30B

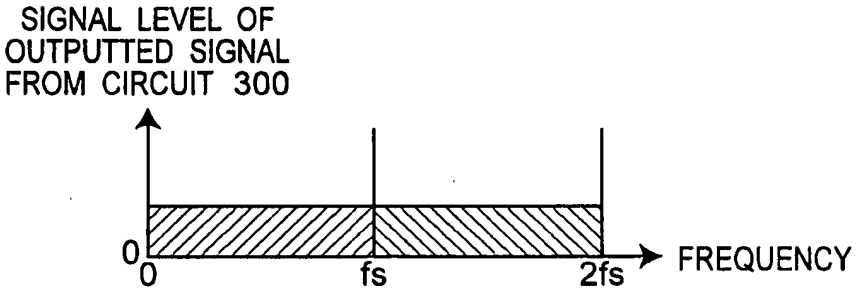


Fig.30C

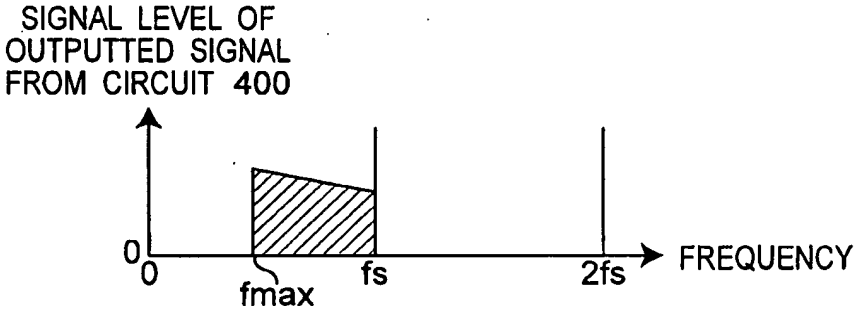


Fig.30D

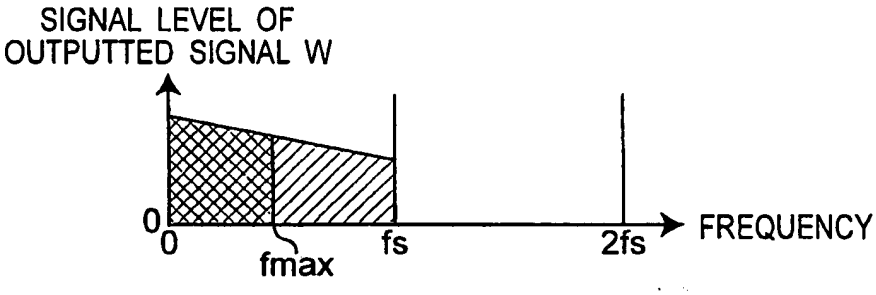


Fig.31A

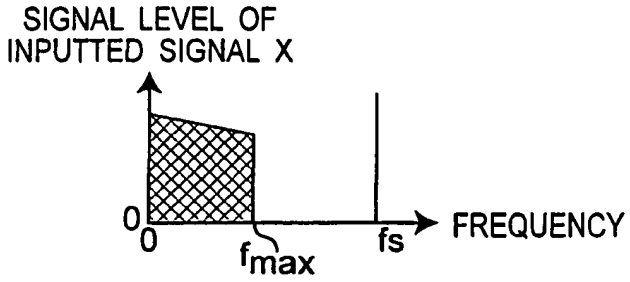


Fig.31B

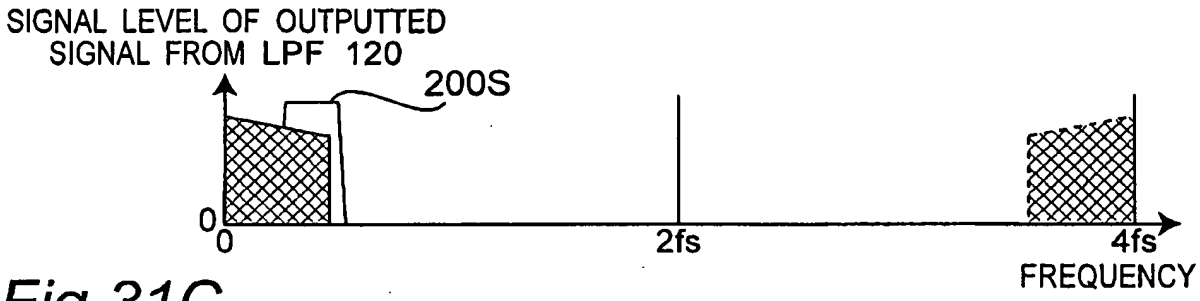


Fig.31C

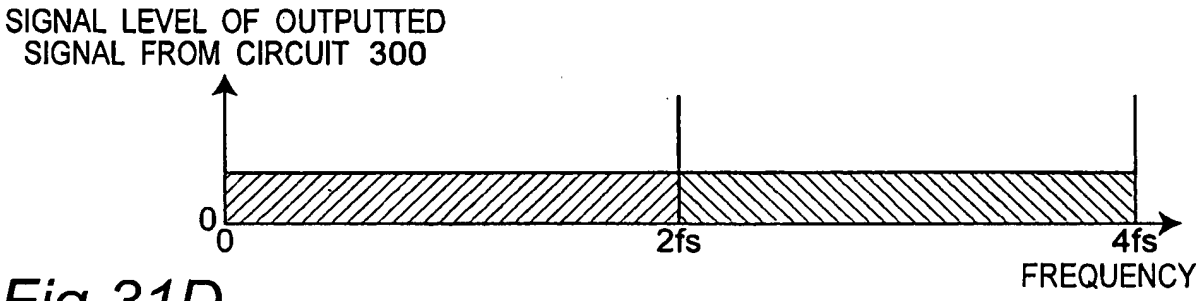


Fig.31D

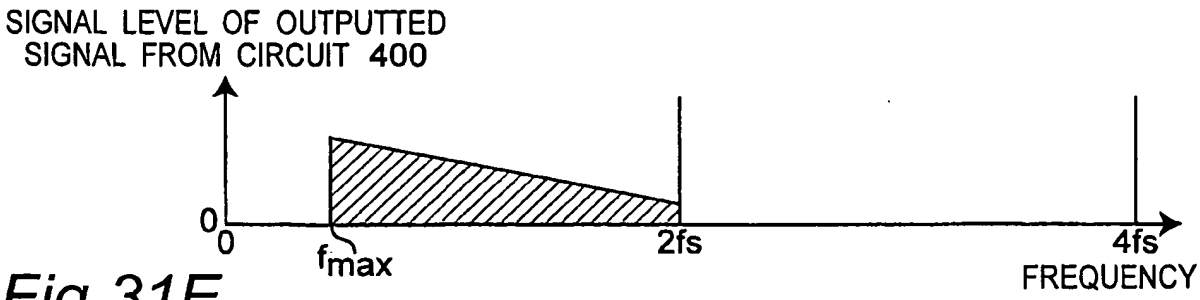


Fig.31E

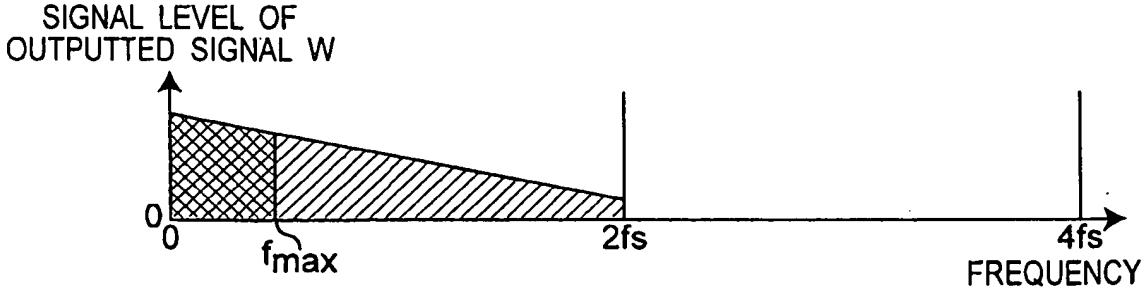


Fig.32A

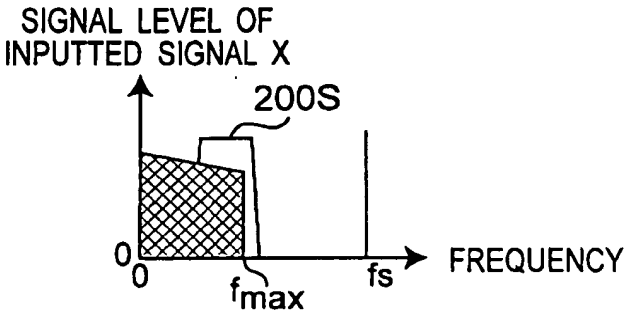


Fig.32B

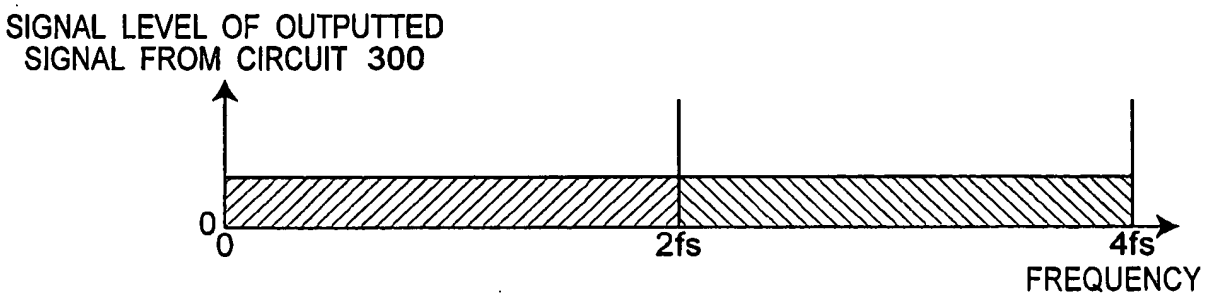


Fig.32C

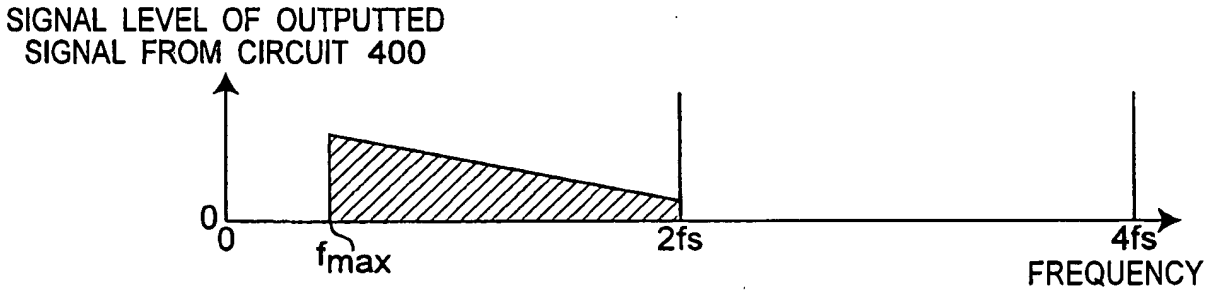


Fig.32D

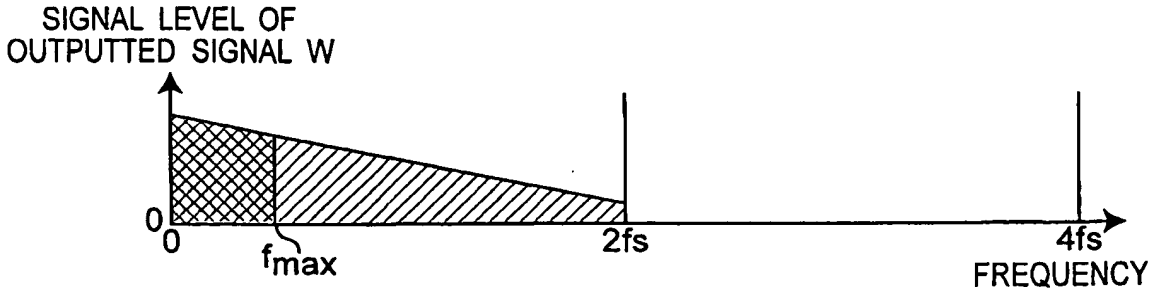


Fig.33A

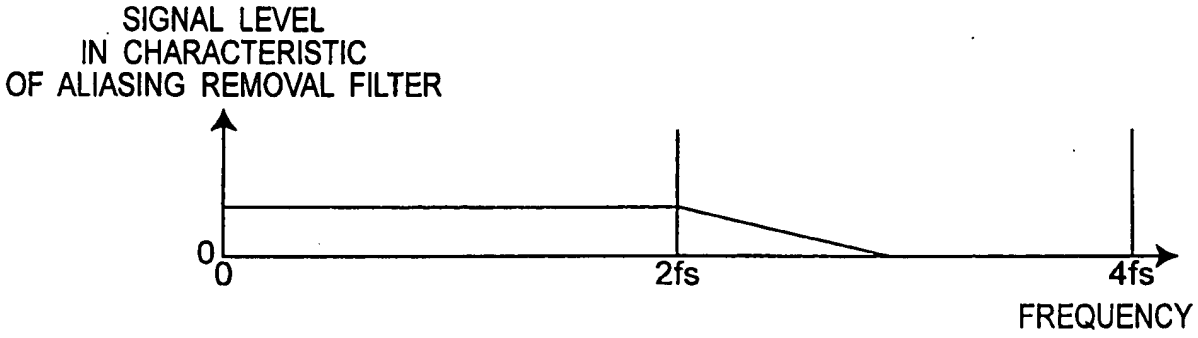
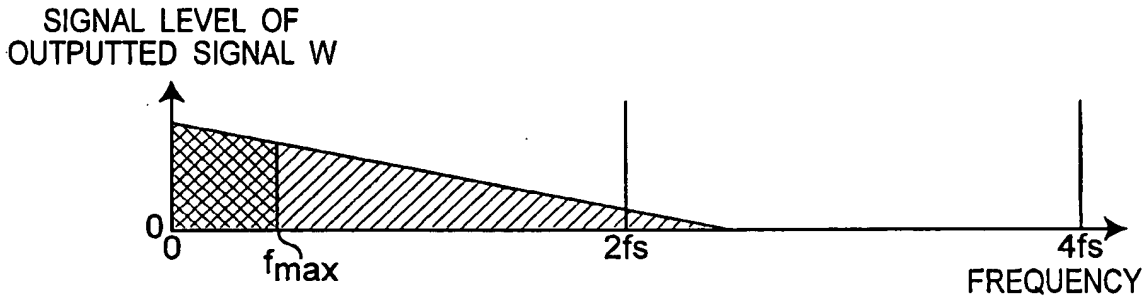


Fig.33B



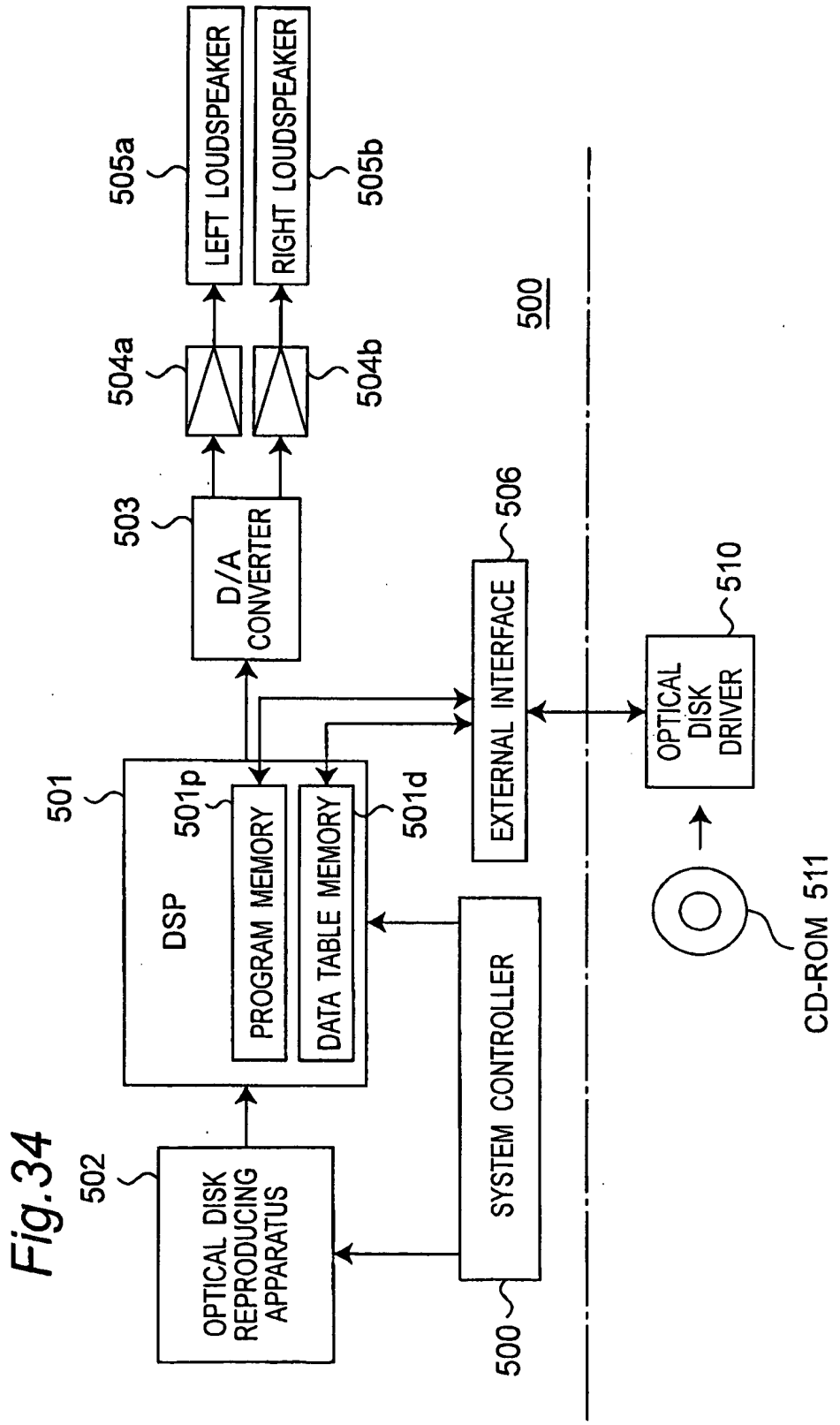

505a
LEFT LOUDSPEAKER
505b
RIGHT LOUDSPEAKER
504a
504b
503
D/A CONVERTER
500
506
EXTERNAL INTERFACE
510
OPTICAL DISK DRIVER
501
501p
DSP
PROGRAM MEMORY
DATA TABLE MEMORY
501d
CD-ROM 511
502
OPTICAL DISK REPRODUCING APPARATUS
SYSTEM CONTROLLER
500

Fig.34